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OCS Study
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California, Oregon, and Washington Archaeological Resource Study

Volume IV: History

Project Editors

Robert L. Gearhart II
Clell L. Bond
Steven D. Hoyt

Volume IV Authors

Robert L. Gearhart II
John C. Neville
Steven D. Hoyt

Prepared under MMS Contract
14-35-0001-30439
by
Espey, Huston & Associates, Inc.
P.O. Box 519
Austin, Texas 78767

Subcontractor:
Dames & Moore
San Diego, California

Published by

U.S. Department of the Interior
Minerals Management Service
Pacific OCS Region

Camarillo, CA
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ABSTRACT

In May 1989, the Pacific OCS Region of MMS contracted with Espey, Huston & Associates, Inc. (EH&A) of Austin, Texas to conduct a study of the OCS between Morro Bay, California and the Canadian Border. Overviews are presented for late Pleistocene/Holocene geology of the OCS, for prehistory of the coastal zone, and for maritime history of the study area. Models are formulated to predict the areas in which prehistoric and historic archaeological sites are likely to be preserved on the OCS. Variables considered by these models include late Pleistocene and Holocene geology of the OCS, known archaeological site distributions, prehistoric settlement patterns, vessel traffic patterns, and the distribution of significant hazardous weather conditions. Holocene geology, known site distributions, and archaeological site predictive zones resulting from this project have been mapped at a scale of 1:250,000 and are bound as an atlas for inhouse use by MMS. Smaller scale copies of these maps, lacking specific locational information for archaeological sites, have been produced for public distribution. The results of this study will be used in evaluating exploration, development and transportation plans for mineral development activities on the OCS and in determining remote-sensing survey requirements that will apply to specific areas of the OCS.

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Cover: Wreck of the Lumber Schooner *Reporter* on Ocean Beach in San Francisco; 1902 photography courtesy of the National Maritime Museum, San Francisco.

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This study was coordinated by Mr. Robert Gearhart, EH&A Senior Staff archaeologist, with the assistance of Mr. Clell Bond, EH&A Vice President and manager of EH&A's cultural resources group. Together, Mr. Gearhart and Mr. Bond were responsible for the organization, editing and final content of these six volumes. Editorial assistance was contributed by Mr. Steven Hoyt, EH&A staff archaeologist. Principal Investigators for this study were: Mr. Robert Gearhart (responsible for historic and marine archaeology); Dr. Pandora Snethkamp (D&M archaeologist responsible for California prehistory); Dr. Gary Wessen (D&M archaeologist responsible for Washington and Oregon prehistory); and Mr. Kim Marcus (D&M geologist responsible for geology). Contributing authors, in alphabetical order, include: Mr. Jim Anderson (D&M geologist); Dr. James Cleland (D&M archaeologist); Mr. Robert Gearhart; Mr. Steven Hoyt; Mr. Kim Marcus; Mr. John Neville (EH&A archaeologist); Dr. Pandora Snethkamp; Dr. Gary Wessen; Dr. Jerry Wilson (D&M geologist); and Mr. Andrew York (D&M archaeologist). All work performed by D&M for this study was conducted under the supervision of Dr. James Cleland, a senior member of D&M's archaeological staff.

This report was critically reviewed by a Quality Review Board consisting of experts in geology, Pacific coast prehistory and marine archaeology. Our thanks to Dr. Curt Peterson (marine geologist and Assistant Professor with Portland State University), Dr. Lee Lyman (Northwest Coast prehistorian and faculty with the University of Missouri, Columbia), and Mr. J. Barto Arnold III (marine archaeologist with the State of Texas) for serving on the review board.

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1.0 INTRODUCTION

The primary objectives of the historic aspect of this study are to determine locations or likely locations of shipwrecks and other submerged historic sites in the study area (Figure IV-1), to develop an historic site database for the study area, and to map known and predicted offshore historic site locations in the study area. The identification of areas having known historic sites or having a high probability for the occurrence and preservation of such sites will assist the Minerals Management Service (MMS) in managing such cultural resources when planning and permitting mineral exploration and development within the study area. In this regard, the results of the predictive model developed here will aid in determining the type and level of remote sensing survey that will be required in specific areas.

In meeting the above objectives, Espey, Huston & Associates, Inc. (EH&A) conducted a general review of the literature and data describing maritime history and types of ships used along the Pacific coast during the historic period, from early exploration and settlement through 1946. Changes in the types and characteristics of ships through time that would affect their detectability by state-of-the-art remote sensing technology, have been discussed in Volume I as part of a more general discussion of site location on the continental shelf. Volume IV concentrates on setting the historic background of the study area, as it relates to maritime topics, and on developing a model predicting the general locations within the study area likely to contain shipwreck sites.

The development of such a predictive model required the review, analysis and mapping of data pertaining to known shipwrecks, sailing routes and navigational hazards. Locations of known shipwrecks in the study area and historic site predictive zones have been mapped on a set of large-scale (1:250,000) maps as part of this study. Shipwreck locations on these maps are keyed to a computerized shipwreck database by reference numbers placed on the maps at specific wreck locations. Both the large-scale maps and the shipwreck database are maintained by MMS. A small-scale version of this map was designed for public distribution and is included as Volume V of this report. The latter maps do not contain specific locational information regarding shipwrecks; rather they provide readers with a general knowledge of shipwreck distribution within the study area. Maps contained in Volume V are referenced repeatedly throughout the text of this volume, thus it may be helpful to the reader to have a copy of Volume V at hand when reading this volume.

Section 2.0 of this report summarizes the general maritime history of the study area, followed by a discussion of previous maritime archaeological investigations in Section 3.0 and by a summary of results of a literature search pertaining to shipwrecks in Section 4.0. Section 5.0 discusses environmental factors contributing to the loss of vessels along the Pacific coast, then characterizes the distribution of these factors, as well as the distributions of vessel traffic and of known shipwrecks in the study area, and formulates a predictive model for vessel loss based upon the interaction of these variables. Section 6.0 presents a summary and Section 7.0 presents a list of references cited.

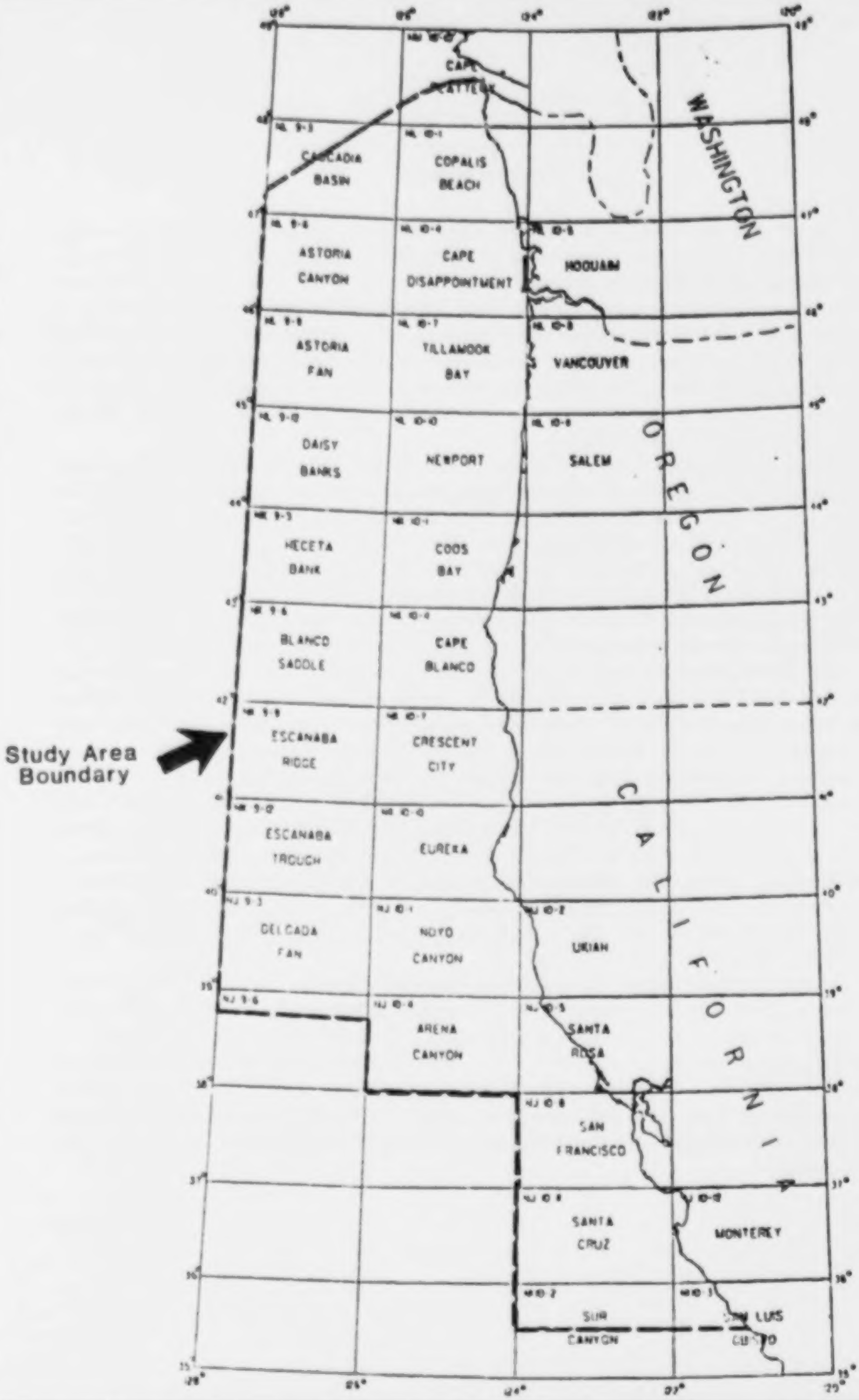
Study Area Boundary
WASHINGTON
OREGON
CALIFORNIA
CAPE FLATTERY
CASCADIA BASIN
COPALIS BEACH
ASTORIA CANYON
CAPE DISAPPOINTMENT
HOQUIAM
ASTORIA FAN
TILLAMOOK BAY
VANCOUVER
DAISY BANKS
NEWPORT
SALEM
HECETA BANK
COOS BAY
BLANCO SADDLE
CAPE BLANCO
ESCANABA RIDGE
CRESCENT CITY
ESCANABA TROUGH
EUREKA
DELGADA FAN
NOYO CANYON
UKIAH
ARENA CANYON
SANTA ROSA
SAN FRANCISCO
SANTA CRUZ
MONTEREY
SUR CANYON
SAN LUIS OBISPO
128°
126°
124°
122°
120°
48°
47°
46°
45°
44°
43°
42°
41°
40°
39°
38°
37°
36°
35°

Figure IV-1. Study Area for the California, Oregon and Washington Archaeological Resource Study.

2.0 HISTORIC BACKGROUND

The maritime history of the United States Pacific coast is a history of imperial competition, commercial adventurism, individual interest, and corporate development. As a result of this complex tangle of historical forces, the region has developed over a period of almost five centuries from a far-flung and sparsely populated outpost of competing European empires into an area whose products and ports are important throughout the world. Any general history of the study area will, to a large degree, be a maritime history.

The detailed and greatly varied history of the area can perhaps be most effectively handled by dividing it into two broad sections: the period of exploration which began at least as early as the first Spanish voyages northward from Mexico in the 1530s, and the period of economic development which began on a large scale in the late eighteenth century after the potential of the area had become widely known in Europe and the United States. Within this division, major trends and events are discussed within their broader historical setting instead of as series of isolated or unconnected phenomena.

2.1 Early Period of Exploration

It is generally accepted that European exploration of the North American Pacific coast began in the early part of the sixteenth century when the Spanish began exploring the territory known as Alta California. Numerous European and American scholars have argued since the late eighteenth century, however, that the Pacific coast was "discovered" and explored at a much earlier date. As early as 1761, M. de Guignes argued that Buddhist monks had sailed across the Pacific Ocean and had explored the American continent (Mertz 1972:xii). The arguments of M. de Guignes and his contemporaries and successors regarding early Chinese voyages to North America and back again were later summarized by Edward Vining in his 1885 book entitled, *An Inglorious Columbus* (cited in Mertz 1972). At about this same time, Charles Wolcott Brooks (1875) published his findings regarding early Japanese shipwrecks in the Americas.

Evidence for transpacific voyages from Asia to North America has continued to accumulate as the result of studies in archaeology, ethnography, history and physical anthropology. Much of this evidence has been summarized in Henriette Mertz's book *Pale Ink*, originally published in 1953 and expanded in a 1972 edition. Despite the growing body of evidence for transpacific contacts, the academic community, as a whole, has been slow to place credence in this hypothesis. Notable recent exceptions include: Ekholm (1953) and Meggers, et al. (1965), both cited in Mertz (1972); Riley et al. (1971); Pierson and Moriarty (1980); Needham and Lu (1985) and Kehoe (1978), the latter two references being cited in Kehoe (1990).

European interest in the west coast of North America began after the Spanish had reached the apex of their conquests in Mexico. In 1522, three years after their arrival in the New World, the conquistadors of Cortes arrived on the shore of the Pacific Ocean. After the great victories and treasures they had won from the Aztec, the Spaniards were eager for new, wealthy lands to conquer. With their gains in Mexico secure, Cortes' men began to explore northward by land in search of more riches and glory. A year after reaching the west coast, Cortes was ordered by Carlos V, the Emperor of Spain, to begin searching for the passage which was believed to connect the Pacific and Atlantic oceans. This channel, known as the "Strait of Anian," was the Spanish equivalent of the British "Northwest Passage."

Although land expeditions to the north brought back tales of pearls and even an "Island of Women", it was not until almost a decade after the Spanish arrival on the shore of the Pacific that the first ship sailed to explore this coast. Under command of Diego Hurtado de

Mendoza, a single vessel was sent out from Acapulco in May 1532. Sailing northward into the Gulf of California, the ship and all hands disappeared (Cook 1973:2). A later expedition found that Mendoza had reached a latitude of at least 27 degrees north near the Rio Fuerte on the Sinaloa coast before the entire crew was wiped out by Indians (Wagner 1966:5).

Perhaps partially in response to the spectacular successes of Pizzaro in Peru, Cortes quickly sent out a second naval expedition. After leaving Acapulco in October 1533, the two ships soon lost contact with each other. Commanded by Hernando de Grijalva, the *San Lazaro* returned to port after discovering the Isla de Santo Tomas and landing on the Colima coast. The second ship, the *Concepcion*, suffered a mutiny in which the captain was killed and the pilot, Ortuno Ximenez de Bertandona, took command. Under Bertandona, the *Concepcion* reached land at what has been identified as the Bahia de la Paz in Baja California. Although most of the crew was killed there, a few survivors managed to return with tales of finding an island rich with gold and pearls (Wagner 1966:6).

Based on the strength of such reports, as well as in obedience to his orders to search for the "Strait of Anian," Cortes himself went to the coast discovered by the crew of the *Concepcion*. Landing in May 1535, he took possession of the land in the name of the Spanish Crown and named it Santa Cruz. A settlement was started at Pichilingue Harbor and parties were sent out to explore the area which was thought to be on an island. In spite of the reports of the *Concepcion*'s men, no great treasures were found and the group returned to Mexico the following year (Cook 1973:3; Wagner 1966:6-7).

Although their initial ventures had not produced the hoped-for results and ended in disaster more than once, tales of fantastic treasure continued to reach Spanish ears and drive explorers northward. For example, Alvar Nunez Cabeza de Vaca arrived in Mexico City with three others in July 1536 after a trek across Texas and Mexico. They told stories of great riches to be found along the shores of the "South Sea" (Pacific Ocean) as well as tales of cities inhabited by "civilized" Indians. Cabeza de Vaca's account largely formed the basis for the legendary "Seven Cities of Cibola" (Wagner 1966:7). According to Marcos de Niza, a Franciscan friar who claimed to have visited these cities in 1539, gold and silver were the only metals the inhabitants were familiar with and its abundance was such that their wealth far surpassed that of any place yet conquered by the Spanish (Cook 1973:3).

In the same year that de Niza supposedly visited the Seven Cities, and probably with the friar's stories fresh in his mind, Cortes tried again. Three new ships were outfitted and sent northward in July 1539 under command of Francisco de Ulloa. Sailing north along the west coast of Mexico, Ulloa explored the head of the Gulf of California before turning south towards Cape San Lucas at the tip of the Baja peninsula. After rounding the cape, Ulloa again headed north and reached a latitude of 30 degrees north at Cabo del Engano. On this voyage it was discovered that California was not an island as had been previously believed, but this knowledge did not gain favor until more than a century later (Cook 1973:3; Wagner 1966:8).

Although there were other expeditions toward the north, the voyage commanded by Juan Rodriguez Cabrillo was the first to reach Alta California (the modern state of California) and the study area (Byrd 1988:10). Leaving Acapulco in 1542, Cabrillo's two ships, the *San Salvador* and the *Victoria*, sailed north past the Santa Barbara Channel and present-day San Francisco but did not discover San Francisco Bay. They travelled as far as the Point Reyes area before being turned back by rough weather. The ships headed south and finally dropped their anchors at San Miguel Island near Santa Barbara where Cabrillo died from injuries. After his death, Bartolome Ferrelo, the pilot of the *Victoria*, took command and resumed the voyage north early in 1543. Ferrelo and his men sighted Point Arena and possibly got as far north as the Eel or Mad rivers near the modern border between California and Oregon. Ferrelo decided to return to Mexico in February 1543 after reaching a latitude perhaps as high as 44 degrees north, the most northerly voyage to that date along the west coast of America (Cook 1973:4; Wagner 1966:72-93).

These first voyages were largely based on the desire of the Spanish to acquire the riches they believed existed to the north of Mexico. In many ways, men like Cortes must have been extremely disappointed in what they found. Instead of golden cities or even a navigable waterway to the Atlantic, they were met with a rugged coastline and often hostile Indians.

2.1.1 Second Wave of Explorations

The dreams of finding new treasures and reaping the economic and strategic advantages that would fall to the nation which discovered and controlled the Strait of Anian were never forgotten. The second phase of Spanish exploration to the far north, however, was largely stimulated by the desire to secure the California coast so that eastbound Manila galleons would have a safe haven after their difficult voyage across the Pacific.

2.1.2 Manila Galleons

Since 1527, Spanish ships had been sailing west across the Pacific, but it was not until 1565 that the eastbound sailing route from the Philippines to Acapulco was discovered. The 40-ton bark *San Luis*, the first vessel to make the crossing successfully, reached the California coast at a latitude of about 27 degrees, 45 minutes but had gone as high as 43 degrees during the course of the voyage (Schurz 1939:180-81). When this route became known, the sailing of a ship from Manila, laden with silks, spices, porcelain and other oriental goods which were in demand in the New World and Spain, became an annual event. The voyages across the Pacific were notoriously difficult and by the time the galleons reached the North American coast, the crews and ships were often in pitiable condition. Despite the hazards posed by the voyage and marauders attracted by the riches aboard them, the Manila galleons continued to be an important part of the Spanish economy and made their annual voyages until almost the end of the Spanish colonial period in America. The Manila trade ended officially in 1815 by a decree of the Cortez de Cadiz opening the Philippines to free trade with non-Spanish merchant vessels (Almazan 1971:30).

2.1.3 British Raiders in the Pacific

The Spanish monopoly along the western shore of the New World came to an end in 1578 when Francis Drake rounded Cape Horn and began attacking Spanish settlements and ships as he made his way north along the coast of South America. In 1579, after reaching a latitude possibly as high as 48 degrees north, Drake turned southward and sailed along the coast of Oregon and northern California to a latitude of approximately 38 degrees, 30 minutes north. Although the exact location is debated, Drake is generally believed to have landed in an inlet north of San Francisco Bay in June 1579 to repair and reprovision his ship. Wherever he actually landed, either Drake's Bay or perhaps farther north at Bodega Bay, Drake claimed the area in the name of the British Crown and christened it Nova Albion. After repairs, the *Golden Hind* sailed west across the Pacific and in September 1580 returned to Plymouth, completing the first British circumnavigation (Howarth 1974:132-141; Thrower 1984:5-8).

Drake's success greatly emboldened other British sailors to take action against the Spanish. The vulnerability of their interests in the Pacific was further demonstrated in 1587 when the Manila galleon *Santa Ana* was looted and burned by Thomas Cavendish near the tip of the Baja Peninsula (Cook 1973:9; Schurz 1939:248-50).

Attacks such as these forced the Spanish to realize that their sovereignty in the Pacific was not entirely accepted by other powers. In response, they began a new series of voyages with two main objectives. The first was to secure the California coast and locate suitable harbors where the incoming Manila galleons could find refuge after the gruelling Pacific crossing (Cook 1973:9-10; Dodd 1986:18). Since it was thought that Cavendish might have entered the Pacific through the Strait of Anian (Dodd 1986:17), the second goal was to locate this long-sought-after channel. After the stinging raids of Drake, Cavendish, and others, the Spanish were eager to find the passage and control it in order to protect their Pacific holdings.

2.1.4 Juan De Fuca

It is within the context of this renewed Spanish interest in locating the Strait of Anian that the enigmatic Juan de Fuca finds his place. In 1596, Michael Lok, a British businessman with interests in the New World met an old Greek sailor named Apostolos Valarianos in Venice. Known to the Spanish as Juan de Fuca, he told Lok that he had served as a seaman and pilot for 40 years in the New World and that in 1592 he had sailed through a passage that took him from the Atlantic into the Pacific. This passage was supposedly located between 47 and 48 degrees north latitude and, naturally, passed through a land rich with gold, silver, and pearls. The question this story raises is not whether Juan de Fuca sailed through this passage, but if he was present on an otherwise-undocumented Spanish voyage or voyages into the far north during the mid- to late sixteenth century when he may have seen the straits which now bear his name. Since the Spanish considered the results of their exploratory voyages to be state secrets, and considering the confusion of the archives in Spain, it is entirely conceivable that a number of voyages in the Pacific are unknown to historians. It is equally possible that Juan de Fuca was simply spinning a yarn in order to gain favor and finance from Lok (Cook 1973:22-29).

2.1.5 New Voyages

The search for a harbor for the Manila galleons began in earnest in 1594 when Sebastian Rodriguez Cermeno was assigned to find a haven along the Alta California coast. Rather than searching up and down the scarcely known coastline for such a port, Cermeno sailed to the Philippines where he boarded the Manila galleon *San Agustin* the following year. After crossing the Pacific, the *San Agustin* arrived off the California coast in November slightly south of the California-Oregon border near Trinidad Head. Sailing south, the vessel made it to Drake's Bay where it was wrecked in a storm. This is the earliest documented shipwreck in the study area (Murphy et al. 1984). The survivors, including Cermeno, eventually returned to civilization in one of the ship's boats (Cook 1973:10-11; Wagner 1966:154-67).

Following the failure of Cermeno, the task of searching the California coast northward from Cape San Lucas to Cape Mendocino fell to Sebastian Vizcaino. In May 1602, Vizcaino left Acapulco with three ships: the *San Diego*, the *Santo Tomas*, and the *Tres Reyes*. After exploring as far north as Monterey, the *Santo Tomas* returned to Mexico carrying those too ill to continue the voyage. By January 1603, the *San Diego*, commanded by Vizcaino himself, reached a latitude of 43 degrees North before turning back due to sickness among the crew. Upon turning south, the ship was caught in a very violent storm which nearly capsized her. After being blown about at the mercy of the sea, the *San Diego* finally reached land again at 42 degrees north latitude. The point of landing was christened Cape San Sebastian after Vizcaino's patron saint. The *San Diego* sailed for Mexico as soon as winds allowed.

The *Tres Reyes*, originally commanded by Martin de Aguilar, sailed the farthest north of the three ships, eventually reaching a latitude of around 43 degrees. During the voyage, the captain and first pilot died and Boatswain Esteban Lopez took command. Upon assuming command, Lopez turned the vessel south to return to Mexico. While along the coast, Lopez discovered the mouth of a river and large bay at about 40 degrees North latitude which he named Rio de Martin Aguilar. Since there are no known original logs or records from the *Tres Reyes*, the accounts of the ship's voyage and discovery are not clear. It has been suggested, though, that the Rio de Martin Aguilar may be the mouth of Humboldt Bay (Cook 1973:11-14; Byrd 1988:11).

2.1.6 Hiatus in Spanish Exploration: 1603-1774

The return of the *Treys Reyes* marked the end of the Vizcaino expedition as well as the finish of official Spanish voyages along the coasts of Alta California and the Pacific Northwest for almost two centuries. Although official voyages had ended, there were other visitors to these coasts during the ensuing period, including survivors both from Japanese shipwrecks (Brooks 1875) and from Manila galleons.

At least one Manila galleon has wrecked on the study area shores. Since at least the early nineteenth century, Nehalem Beach, slightly south of the mouth of the Columbia River, has been known for the chunks of beeswax found there. These pieces of wax have weighed as much as 75 pounds, and some have letters, numerals, or other markings on them (Strafford 1908). Beeswax from Asia was a common cargo aboard Manila galleons, and the wax and other artifacts found in the area suggest a Spanish shipwreck. Through a process of elimination, the galleon *San Francisco Xavier* has been identified as the ship most likely to be the "Nehalem Beeswax Ship". With a cargo which included several tons of beeswax, the ship left Manila in early 1707 and was never seen again (Cook 1973:33-34; Schurz 1939:211). Encounters of later explorers to the region with light-skinned red-haired Indians, thought to be descended from shipwrecked sailors, create a compelling story of an early Spanish misfortune on the northwest coast (Cook 1973:35-6; Thwaites 1904-05:vol.3, 301).

Although it had not been especially swift, Spanish exploration and mapping along the coast of Alta California and the Pacific Northwest had gone on steadily for nearly 100 years. These voyages were abruptly stopped after the return of Vizcaino in 1603. It was thought that once the channel had been found, the route through it could not remain a secret for long and that controlling it would prove to be an impossible task. Raiders such as Drake and Cavendish were doubtlessly still fresh in the minds of the Spanish decision makers, but despite the real threat they posed, the Pacific was still largely a Spanish lake at the beginning of the seventeenth century (Cook 1973:17-20).

The foreign threat feared by the Spanish did not begin to appear for almost 150 years. Between the return of Vizcaino in 1603 and Bering's voyages in the early eighteenth century, the Spanish were effectively the sole European power on the Pacific coast. Unfortunately for them, they did nothing to consolidate their advantages and the Pacific coast was left much as they had found it. By the time they reacted to the entry of other powers, the Spanish Empire had grown too weak to stop the trickle of explorers which was soon to become a flood of traders, merchants, and eventually settlers.

2.1.7 Russians in the North Pacific

Ironically, the first European threat to what the Spanish saw as part of their empire arrived in the north Pacific by land and not through the Strait of Anian. Under Peter the Great, the Russian Empire had expanded rapidly across Siberia with fur trappers and traders among the vanguard. These men were well-established on the shores of the north Pacific at Kamchatka and in the Kurile Islands by the time Vitus Bering began his first voyage along the coast in 1728 (Golden 1968:vol.I, 4-5).

Sailing from Petropavlovsk in 1741 with the *St. Peter* and *St. Paul*, Bering and Alexsei Chirikov explored southward. Chirikov sailed as far south as 47 degrees, but his southernmost sighting of land was at around 55 degrees north latitude. Bering did not get as far south, but the discoveries of his men were to have a far greater impact on the Pacific Northwest. The *St. Peter* was wrecked on Bering Island, and those who survived the winter did so largely because of the population of sea otters there (Golden 1968:vol.II, 147-148). Sustained by the food and warm clothes that the animals provided, they built a raft and sailed back to Petropavlovsk. The survivors brought a number of sea otter pelts with them which were sold to Chinese merchants who were trading at Petropavlovsk when the castaways arrived. The great profits realized from these furs brought about intensive sea otter trapping in the North Pacific. Russian fur hunters soon became a common sight in the Aleutians. Because populations of sea otters were quickly depleted by hunting and trapping, the Russian fur men began to follow the supply of animals eastward along the Aleutian chain and finally south toward the areas claimed by Spain (Huculak 1971:9-10).

Russian activities in the Pacific did not go unnoticed by the Spanish, but initially they did not seem concerned. During the 1760s, however, this attitude began to change. A report was received which indicated the Russians were preparing for a major round of explorations to the North American mainland. Fear of Russian encroachment caused the Spanish to begin formulating plans to colonize the coast of Alta California. The harbor at San Blas, east of Cape San Lucas, was chosen to be the site of a new naval base which would support the coming expansion into the north (Thurman 1963:65-77). In early 1768, the order was received to occupy Monterey, California and place outposts along the coast of Alta California. The plan for occupation involved the placing of missions at strategic locations along the coastline and inland in order create a permanent Spanish presence and convert the native populations to Catholicism. It was hoped that this would be enough to deter the Russians from any colonial plans they had for the area.

2.1.8 Voyages in Reaction to the Russian Threat

By the 1770s, the Russian presence in the northern Pacific had become too much for the Spanish to bear. Finally roused to action by fear of intervention in the vast wilderness which they claimed as their own, the Spanish authorized the first official voyages of exploration since 1603 (Barratt 1981:68). Juan Jose Perez sailed in January 1774 with the 225-ton frigate *Santiago* (also known as the *Nueva Galicia*) under his command. His orders were to travel as far north as possible in order to assess the Russian presence, study the Indians, take possession of new lands, and survey possible sites for future Spanish settlements. Following visits to both San Diego and Monterey, Perez began the long voyage north. After sailing from Monterey, he did not sight land again until mid-July near the modern border between Alaska and Canada.

Working southward from this latitude, the *Santiago* arrived at Vancouver Island in early August, and became the first vessel to enter Nootka Sound. While trading with the Indians, a pair of silver spoons belonging to pilot Esteban Jose Martinez were stolen. After leaving Nootka

Sound, Perez continued to sail south. He passed the Strait of Juan de Fuca without mention and arrived back at San Blas that autumn. During the entire voyage, Perez neither landed nor performed a single act of possession. Since the act of possession was a ceremony designed to mark new territory and serve notice that it had been claimed for the Spanish crown, it was considered fundamental to the assertion of Spanish sovereignty (Wagner 1938:297-326). Intended to give the Spanish a solid claim to the dominion of the areas explored, the voyage produced little more than a very rough description of the coast which Perez had followed. Since Perez did not take possession of any part of the coastline, the spoons which Martinez had lost at Nootka were to take on new importance in a few years as the only evidence of earlier Spanish presence at Nootka Sound when the area came into dispute.

Perez not only failed to claim any territory, but his findings did little to allay Spanish fears of Russian encroachment. The following year, Bruno de Hezeta was sent north with a similar mission. With two ships, the *Santiago* and the *Sonora*, he sailed from San Blas on 16 March 1775, hoping to reach a latitude of 65 degrees. In July, shortly after arriving at a place which has been identified as Point Grenville on the Washington coast, Hezeta began to consider the possibility of returning to Mexico. The entire crew of the *Santiago* was ill and he feared that if they remained at sea much longer, there would not be enough able-bodied men to handle the ship. Hezeta eventually sailed as far north as 49 degrees before turning back. During the return trip, he stayed as close as possible to the coast in order to complete the survey as he had been ordered. This care, however, did not keep him from missing the entrance to the Strait of Juan de Fuca as Perez had.

On August 17, the *Santiago* came to a large bay which Hezeta assumed to be the Strait of Juan de Fuca. He attempted to enter the mouth of this bay but found the current to be such that he could not, even under full sail. Because of the condition of his crew, Hezeta did not try to enter the bay again, but continued south after naming it Bahia de la Asuncion de Nuestra Senora. This bay was actually the mouth of the Columbia River and Hezeta was the first European to report it.

The *Santiago* arrived at Monterey in late August and the crew went ashore to recover from their ordeal and await the arrival of the *Sonora*, which had been separated from the *Santiago* since July. Although it was common for sailing ships to become separated on long voyages, the *Sonora* was a 36-foot (ft) long schooner and was never intended for use in rough northern waters. Nevertheless, the *Sonora*, under command of Juan Francisco de la Bodega y Quadra, far surpassed the accomplishments of the much larger *Santiago*. Bodega apparently detached the *Sonora* from the *Santiago* intentionally. He was determined to carry out his orders and had become disgusted with the officers aboard the other ship because they were so eager to return home before completing their mission.

After leaving the *Santiago* behind, the *Sonora* continued northward until land was again sighted at about 57 degrees latitude. Bodega turned south mapping much of the coastline and reaching a maximum latitude of 58 degrees, 30 minutes. During the return voyage, the Sonora's crew was so stricken with scurvy that the officers were forced to perform common seaman's tasks, and even then they were shorthanded. Despite these conditions, they were able to locate and map Tomales Bay slightly to the south of Bodega Bay. Finally reaching Monterey on 7 October, Bodega was so ill that he had to be carried from the vessel, and it was another month before the crew recovered enough to sail for Mexico.

During this voyage, four acts of possession were carried out at high latitudes and no trace of the Russians had been found. With the Russian threat seeming much less important, the

Spanish began to shift their efforts away from exploration in the far north in order to better support the new settlements which they had placed in Alta California.

2.1.9 Voyage of Captain Cook

Even though the voyages had been kept in strict secrecy, the renewal of Spanish exploration along the northwest coast was noted by other European powers. Because of increasing British interest in the economic and colonial potential of the west coast, as well as a desire to collect a 20,000 pound reward which Parliament had been offering to the discoverer of the Northwest Passage, the British Admiralty proposed a voyage to the Pacific Northwest to be commanded by Captain James Cook. The success of his previous two voyages into the Pacific had made Cook the most respected navigator in the world and the ideal choice to lead the voyage. With orders to search for the Northwest Passage, "inventory the natural environment; and take possession of any unclaimed territory", Cook's two ships, the *Resolution* and the *Discovery*, weighed anchor at Liverpool on 12 July 1776.

Sailing east across the Pacific, Cook stopped at New Zealand, Tasmania, Tahiti, and discovered the Hawaiian Islands before arriving off the Oregon coast near Cape Foulweather on 7 March 1778. Heading north, Cook passed both the mouth of the Columbia River and the Straits of Juan de Fuca before arriving at Nootka Sound on the west coast of Vancouver Island on March 29. Cook and his men spent almost a month at Nootka making repairs on their ships, studying the Indians there, and trading with them. It was during this stay at Nootka that Cook's men received in trade the sea otter pelts which were to quickly transform the Pacific Northwest into a busy commercial area with the fur trade centered at Nootka Sound. The two silver spoons which had been taken from Martinez in 1774 were also traded (Holmes 1982:71). Upon leaving Nootka, Cook continued up the coast of Alaska and into the Bering Strait. After attempting unsuccessfully to sail into the Arctic Ocean, the expedition turned south and reached the Hawaiian Islands, where Cook was killed in a fight with the natives. The *Resolution* and *Discovery* continued the voyage to China, where the sea otter pelts collected at Nootka for trifling prices were sold to the Chinese merchants at great profit (Holmes 1982:154). When they saw how much the furs were worth, the British sailors wanted to return to Nootka immediately. The officers of the ships faced a near mutiny before they were able to get control (Ogden 1941:82).

2.1.10 Laperouse Expedition

The successes of Cook attracted the attention of other European powers. In the summer of 1785, French King Louis XVI sent two ships under the command of Jean Francois de Galaup Laperouse into the Pacific on an elaborate voyage of exploration. The *Boussole* and the *Astrolab* arrived off the Alaskan coast around 59 degrees North latitude in late June 1786 and began to explore southward toward Monterey. Under orders similar to those of Cook, Laperouse was to explore the Pacific Ocean and the west coast of North America with an eye towards colonial and economic opportunities, assess the activities of other powers in the region, and continue the search for the Northwest Passage. The French left the coast of America in 1787 after reaching their southerly goal of Monterey (Valentin 1969:27-52). Unfortunately, most of the expedition was lost after both vessels were wrecked in the Santa Cruz Islands the following year. Because of the internal problems faced by the French in the last years of the eighteenth century, the Laperouse expedition was not followed up by other official French voyages.

2.1.11 Vancouver Expedition

The British Admiralty was quick to follow up on the success of Cook's expedition. After studying the reports and logs from that voyage, an expedition under command of George Vancouver was sent out in 1792 with orders to thoroughly study and survey the coast between 30 and 60 degrees North latitude. His orders also contained specific instructions to look for the Straits of Juan de Fuca as well as any inlets or rivers which might connect with bodies of water farther inland. In keeping with the growing competition for the area, Vancouver was also to assess the strength of any other Europeans in the area he was to explore.

Surveying between San Diego and Kodiak Island, Vancouver carried out his orders well. Although he did not name it, his men explored almost 120 miles up the Columbia River, made the first voyages into Puget Sound, and took possession of the area for the King. This expedition, which lasted until 1794, had two major impacts upon the exploration of the Pacific Northwest. The search for the Northwest Passage came to an end after being sought since the earliest days of the New World, and the British gained rights to the uncolonized area between Russian Alaska and Spanish California.

2.2 Early Economic Development

The Pacific Coast was relatively slow to develop economically considering the early arrival of European explorers to this region. The economic climate of the Pacific coast during the early years of the nineteenth century was very much that of a frontier. The economy was not self-sustaining. Were it not for markets on the east coast and abroad for the resources available in the region, namely furs, cowhides, whale products, and, to a lesser extent, lumber, economic development prior to the gold rush would not likely have proceeded to the point that it had by 1848. Over time, secondary industries developed in the region to support the commerce in these primary products. For example, provisioning and repair of whaling vessels developed as an industry in San Francisco and other west coast harbors in support of the larger whaling industry as it existed throughout the Pacific Ocean in the nineteenth century (Starbuck 1878). To a large extent, the lumber trade also developed as a secondary industry in support of transpacific maritime commerce during the first half of the nineteenth century.

2.2.1 The Fur Trade

The earliest major economic development in the region was the international trade of furs, most important of which were sea otter pelts. Sea otters have been called the lodestone which first brought Europeans to the Pacific coast in large numbers (Cook 1973:42). The sea otter (*Enhydra lutris*), was found along the Pacific Rim from the northern Japanese islands down the coast of North America at least as far south as the Baja Peninsula. William Sturgis, a trader, historian and early naturalist, aptly summarized the qualities of otter pelts.

> "A full grown prime skin which has been stretched before drying is about five feet long, and 24 to 30 inches wide, covered with very fine fur about 3/4 of an inch in length, having a rich jet black glossy surface and exhibiting a silver color when blown open. Those are esteemed the finest skins which have some white hairs interspersed and scattered over the whole surface, and a perfectly white head". Sturgis, who made his first voyage to the Pacific Northwest in 1798, personally considered the skins

of sea otters "as among the most attractive natural objects that can be placed before him." (Vaughn 1982:3-4).

The Russians had been obtaining sea otter pelts and trading them with the Chinese since the 1740s. Russian fur hunters and traders started in the Aleutian Islands and, utilizing the skills of the local hunters, began obtaining furs on a large scale. The Russians used native Aleut hunters to obtain their supply of sea otter furs. Using both one and two man *baidarkas* or *kayaks*, they hunted alone or in groups and proved very effective in catching the wily sea otters. The Russians found the Aleuts to be so skilled that they kept the hunters with them, often under conditions which were little better that slavery.

As sea otters were eliminated from their northern habitats, Russian hunting operations began to move towards the south in order to maintain profit levels (Barratt 1981:99). Female sea otters have only a single pup at a time and do not reproduce yearly. This low rate of reproduction ensured that intensive hunting was disastrous to local populations of the animals (Vaughn 1982:4). This southward expansion came under the control of the Russian-American Company when Tsar Paul I granted the company a monopoly for hunting the otters (Barratt 1981:100).

The continual depletion of northern sea otter populations was not the only force which drew the Russians toward the territories claimed by Spain. Operating from their North American base at Novo-Arkhangel'sk (modern Sitka, Alaska), the Russians were even more isolated than their Spanish counterparts in the outposts of Alta California. Because Novo-Arkhangel'sk was often besieged by the local Tlingit Indians and resupply from Russia was undependable, the Russians began to look to Spanish California as a source of supplies (Barratt 1981:149).

Sea otters were well known to the Spanish as well, and as early as 1733, a writer commented on their abundance along the coast of Baja California. Although they were never able to exploit them to the same degree, the Spanish were not far behind the Russians in realizing the commercial value of sea otter pelts. When it was known how much the Chinese would pay for them, sea otter furs became regular trade items being sent to the east and in 1786 the Spanish formulated an official plan for exploiting the animals. This plan did not come to fruition. Because neither the Spanish nor the Indians in California had the skills to effectively hunt them, a relatively small number of animals were taken along the California coast until the arrival of the American and Russian fur men in the early nineteenth century (Ogden 1941:2).

The economic potential of the otter skin trade was not realized on a large scale until after the results of Captain Cook's visit to the region were published. This report and the efforts of crewmen from the Cook expedition, such as the ambitious American John Ledyard, publicized the fact that there was wealth to be had there in the form of sea otters. The British were quick to exploit the knowledge gained during the Cook expedition about the value of sea otter pelts. The official report of the voyage was published in 1784, and the first British fur ship arrived at Nootka Sound the following year. The *Harmon* had sailed from China under command of James Hanna and left the area after trading for furs which were later sold for over 20,000 Spanish dollars in China. By the time Hanna returned the next year aboard the *Sea Otter*, Nootka Sound was the recognized center of the fur trade in the Pacific Northwest (Cook 1973:100-101). Between 1785 and 1794, 35 British vessels arrived in the northwest to take part in this trade (Vaughn 1976:86).

Americans also first learned of the possibilities of the sea otter trade from John Ledyard. Ledyard had served as a marine aboard the *Resolution* during Cook's voyage and, upon his return to the United States in 1782, began to promote the virtues of the Pacific Northwest. His schemes for opening the northwest to Americans were well-received by such prominent men as John Paul Jones and Thomas Jefferson, but were never implemented. Although he died in 1789 without having any of his plans come to fruition, Ledyard did succeed in making the American business community aware of the possibilities open to them on the northwest coast (Cook 1973:104-06).

Americans were especially receptive to the idea of using the resources of the Pacific Northwest to turn a profit. One of the side effects of gaining independence was that Americans lost access to the British markets which they had depended upon heavily for overseas trade. With their traditional markets closed and Ledyard's reports of the Pacific Northwest fresh in their minds, many American merchants and sea captains began to look to that area. The first American vessels to arrive at Nootka Sound with the intention of trading for furs were the *Columbia* and the *Lady Washington*. Commanded by John Kendrick and Robert Gray, respectively, the two ships arrived in September 1788. After wintering at Nootka, Gray took over command of the *Columbia* in mid-1789 (Cook 1973:106 n.49).

One of the hallmarks of fur trading voyages was that they were exploratory as well as commercial. British and American fur traders did their part to explore the little-known coastline of the Pacific Northwest. For example, Charles William Barkley, captain of the British vessel *Imperial Eagle*, was probably the first European to note the entrance to the Strait of Juan de Fuca (Cook 1973:103). Robert Gray completed the first American circumnavigation upon his return to Boston in 1790 (Vaughn 1976:83), and on a second voyage in 1792 was able to explore the coasts of Washington and Oregon, discovering Gray's Harbor and entering the mouth of the Columbia River.

Although the British had a greater presence in the Pacific Northwest in the late 1780s and early 1790s and other European powers were showing interest in the area, events on the continent left the Americans in a dominant position. By the late eighteenth century, the Spanish Empire was in a state of serious decline, and beginning in 1789, Europe was involved in a period of revolution and war which would not end until 1815 (Huculak 1971:19; Vaughn 1976:85). By default, Americans became the most powerful nationality in the Pacific Northwest. Between 1785 and 1794, only 15 American trading vessels visited the northwest, but in the next ten years that number increased to 50 while the number of British ships dropped to 9 (Vaughn 1976:86).

Even though the focal point of the sea otter trade was at Nootka Sound, British and American fur men obtained many of their pelts by travelling along the coastline from village to village and trading with local Indians. At first the prices for pelts were very low, and they could be bartered for with simple trade goods such as beads and pieces of cloth or metal. The Indians were very skilled traders, however, and soon began to receive more significant items, such as firearms, in exchange for their furs. The Americans traded in a "no holds barred" style which became characteristic of the Yankee traders. Fairburn described the low point of the American dealings for furs:

> Americans were guilty of many shady transactions on the Northwest Coast in their quest for furs, but none was worse than their dealings in slaves in order to obtain the skins of sea otters. Finding that war-captives were a recognized form of wealth among the Indians, some Boston traders bought these slaves from tribes that were overstocked, with the price correspondingly low, and sold them very profitably to other tribes that were short on slaves and, therefore, put a high price on them (Fairburn 1944-1955:508).

As northern sea otter populations declined, both the Russian and American fur men encountered new difficulties. Perhaps because of the nature of the shoreline, there was a gap in the sea otter habitat between the Strait of Juan de Fuca and the coast of northern California (Ogden 1941:6). This break meant that when the sea otter population in the Nootka Sound area was exhausted toward the end of the eighteenth century, the southward-moving fur men were forced to move almost directly into Spanish territory. Since foreigners had been forbidden from trading at Spanish ports or hunting in their waters, there could be no Russian hunters or American traders working in San Francisco Bay or south of there without risking a potentially violent encounter with the Spanish authorities (Ogden 1941:49-56).

Even though they were competing for the same resource, the Russian and American fur men were able to cooperate when faced with the difficulties of operating in California. An 1803 agreement between prominent fur trader Captain Joseph O'Cain and Alexander Baranov, the phlegmatic director of the Russian-American Company, placed Aleutian hunters and their *baidarkas* aboard American ships during forays into Spanish territory (Ogden 1941:45). Splitting the furs equally, this arrangement proved very profitable for both parties. The Aleuts brought in large numbers of pelts, and the Americans provided transportation and protection (Ogden 1941:52). In order to gain access to Spanish ports, the fur men would often claim ship damage or some other difficulty (Ogden 1941:41-44). Once in position, the Aleuts would hunt while the American ship provided a base of operations and protection. Ironically, in parts of California the Spanish forces were so weak that they were effectively held prisoner by the heavily armed trading vessels while the hunters did their work (Ogden 1941).

American vessels often circumnavigated the globe during their fur trading voyages. Usually sailing from Boston, the ships would head south down the coasts of North and South America. After rounding Cape Horn, they would sail for the fur trading areas on the northwest coast. When they had acquired a satisfactory load of furs, the ships would head for Canton, often with a stop in Hawaii in between. Returning by way of the Indian Ocean, they would sail around the Cape of Good Hope and then across the Atlantic to Boston (Fairburn 1944-1955:509). During the year 1805-06, Americans carried out trade valued at around five million dollars with the Chinese at Canton. Twenty percent of the total value of this trade was accounted for by the Pacific coast fur traders. In that year, 17,445 sea otter pelts, 140,279 seal and 34,460 beaver skins were brought into Canton (Fairburn 1944-1955:508).

By the 1820s, the fur trade based on sea otters was largely finished. The ceaseless hunting had almost completely exterminated the animals. They were seldom seen in areas where they had once been plentiful, and it was not until the twentieth century that they slowly began to recover. One writer commented with great excitement about a small colony found along the California coast during the 1930s but did not seem overly sanguine about their chances for survival. Although there had always been a market for other types of fur, it was not until the supply of sea otter was exhausted that these began to play a more important monetary role in the fur trade along the west coast. Fur seal, sea lion, and walrus all became more prominent targets for the fur hunters, and each in its turn was hunted to the edge of extinction.

2.2.2 Hides and Tallow

As the fur trade began to wane during the early nineteenth century, a thriving cattle industry was developing in the then Mexican territory of California. In 1824 the economic potential of trade in cattle hides and tallow was demonstrated when the *Sachem* returned from California to Boston with a cargo of hides that turned a good profit (Delgado 1990:4). Trade in hide and tallow was the mainstay of California's maritime economy from the early 1820s until the gold rush began in 1848, although it remained relatively limited until the 1840s. During the 1830s, for example, there were reportedly as few as eight ships involved in the California hide and tallow trade (Issel and Cherny 1986:10). It has been estimated, however, that 200 vessels were involved in this trade between 1800 and 1847, exporting 5,000,000 hides from California (Davis 1967:281 cited in Delgado 1990:5).

2.2.3 *Whaling*

At about the same time that the hide and tallow trade was developing in California, whaling was also beginning to play a factor in the economy of the region. The whaling industry had begun moving into the Pacific Ocean by the 1790s, although it took several years for whaling to take hold in this area and for whaling ports to develop on the Pacific coast that could provide support for the whaling fleet. Following 1817 Pacific whaling experienced a major rise in popularity as a result of an exceptionally large return of sperm oil from the Pacific in that year. For the first time on record, the take of sperm oil had exceeded one million gallons (Fairburn 1945:1001). By the 1820s whaling vessels were calling regularly on California harbor towns (Delgado 1990:6-7).

This was the beginning of what has been called the golden era of whaling, a period of about 50 years between 1829 to around 1880. In 1829 the entire U.S. whaling fleet consisted of 203 vessels totalling 57,284 tons. This was approximately 10 percent of the U.S. merchant fleet. The size of the U.S. whaling fleet increased steadily and by 1840 totalled 554 ships. The fleet tonnage peaked for all time in 1858 at 198,594 tons. The busiest whaling years were those from 1845 through 1859 during which the average annual fleet tonnage was 186,436 tons (Fairburn 1945:1002-1011). During this heyday of whaling Matthew Fontaine Maury, a pioneer in oceanography, published his famous whale chart series. Maury's whale chart for the Pacific Ocean is reproduced below as Figure IV-2.

The trade between California merchants and whalers intensified during the 1840s and continued well beyond the period of the gold rush. The drilling of the first oil well at Titusville, Pennsylvania in 1859 quickly led to the development of petroleum-based lubricants and fuel oil and brought a rapid decline in the demand for whale oil. The decline in whaling was hastened by the outbreak of the Civil War. Between the peak year of 1858 and 1862 the total tonnage of the U.S. whaling fleet dropped precipitously by 41 percent (Fairburn 1945:1011). Within a decade of 1858 the fleet tonnage was down by 60 percent to 78,486 tons, and by 1876 totalled only 39,116 tons, 20 percent of the fleet size in 1858 and about two thirds the size of the fleet when Pacific whaling first took off in the 1820s.

2.2.4 *The Early Lumber Trade*

One of the most significant and long-lasting economic developments to affect the Pacific coast of the United States was the rise of a lumber industry. The early history of lumber trade along the Pacific coast is, however, more that of exploration and settlement than of industry. The sea otter trade had played a large role in the exploration and opening-up of the Pacific coastline. The fur traders, however, were transients who moved on as soon as local sea otter populations were exhausted. The lumber industry was slower to develop; nevertheless, its inception marked the beginning of continuous occupation and economic development of the vast Pacific coast territory that existed outside of major harbors such as San Francisco.

When Europeans first sailed the coasts of Washington and Oregon, they were presented with an almost solid wall of trees. Although the California coast was not as heavily wooded, it had its share of well-timbered areas as well. Although timber resources were not

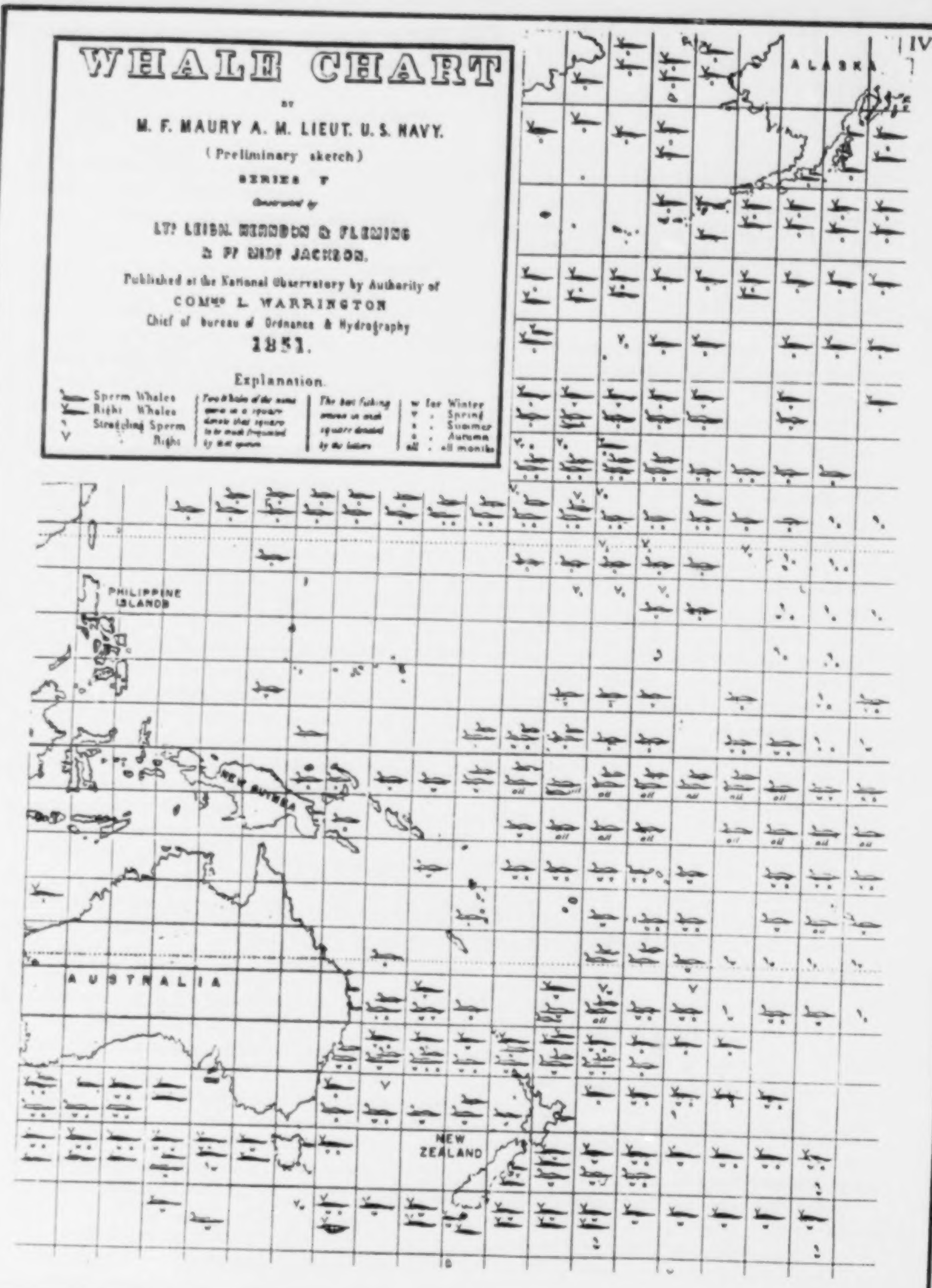
WHALE CHART
BY
M. F. MAURY A. M. LIEUT. U. S. NAVY.
(Preliminary sketch)
SERIES F
Constructed by
LTS LEIGH, HERNDON & FLEMING
& PD MIDN JACKSON.
Published at the National Observatory by Authority of
COMMO L. WARRINGTON
Chief of bureau of Ordnance & Hydrography
1851.
Explanation.
Sperm Whales
Right Whales
Straggling Sperm
Right
Two Whales of the same genus in a square denote that square to be much frequented by that species
The best fishing season in each square denoted by the letters
w for Winter
v Spring
s Summer
a Autumn
all all months
ALASKA
PHILIPPINE ISLANDS
NEW BRITAIN
AUSTRALIA
NEW ZEALAND

Figure IV-2a. Maury Whale Chart of the Pacific Ocean.

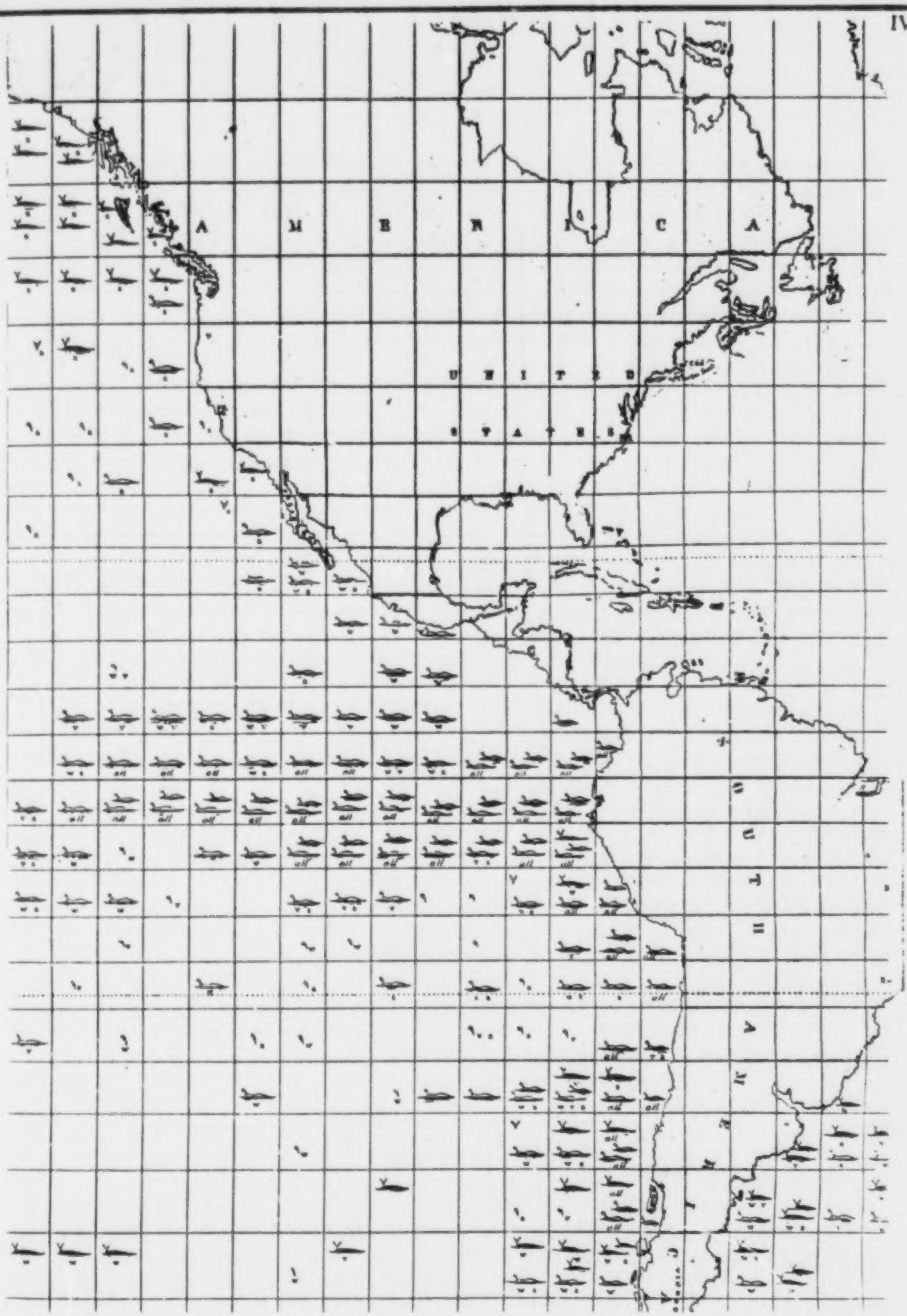
AMERICA
UNITED STATES
SOUTH AM

Figure IV-2b. Maury Whale Chart of the Pacific Ocean.

developed as a major industry until the mid-nineteenth century, a steady and growing demand for lumber coincided with the gradual rise in California's maritime economy and associated settlement.

The earliest need for lumber was undoubtedly for repair of shipboard damage. In 1579, for example, Sir Francis Drake spent almost a month in northern California cutting lumber with which to repair the *Golden Hind*, in preparation for a long, difficult journey across the Pacific (Cox 1974:3). Many other early visitors doubtless did likewise after their ships had been battered in a northern storm or after a rough Pacific crossing (Ficken 1987:8-11).

John Meares, a prominent and controversial fur trader, made the first attempt to gain a profit from the Pacific coast forests. On a fur trading voyage in 1788, he had one of his ships, the *Felice*, supplement its cargo of furs with lumber cut at Nootka Sound. Meares hoped to sell the wood, which had been cut as ships timbers, at Canton along with the sea otter pelts, but unfortunately for him, this first attempt to export timber from the Pacific Northwest was a failure. After the *Felice* had put to sea, a heavy storm developed and the cargo of wood had to be cast overboard (Cox 1974:5-6; Ficken 1987:9).

Almost three centuries after the first European explorers arrived on the west coast, there were so few people living to the north of Mexico that, even in the most heavily populated areas, the demand for wood was minimal. Trees were cut and sawn by hand in saw pits with great whipsaws as lumber was needed (Ficken 1987:11-12). Even if there had been much surplus production, the lack of regular transport meant that there was effectively no way to move it to any export markets on a steady basis.

Small-scale lumber operations were able to supply the needs of the entire west coast until well into the nineteenth century. As the population began to increase, the need for lumber grew as well and the first sawmill in regular operation in the Pacific Northwest was opened in 1827. Built by the Hudson's Bay Company, the mill was located on the north bank of the Columbia River near Fort Vancouver. In addition to producing lumber, this mill was meant to strengthen British territorial claims in the area.

In the years since Meares' first attempt to export lumber, a small amount of wood was transported from the northwestern forest for use in Alta California and South American markets (Cox 1974:6-7). It was not until the early 1830s that the Hudson's Bay Company attempted to take advantage of this export market by using the company's fur trading vessels to carry lumber products during the times of the year when the fur traders were inactive. These ships could be used to carry lumber south to California, Mexico, and beyond or across the Pacific to the Hawaiian Islands and China (Cox 1974:9-10). The lumber export business promised to be very profitable since it was thought that the lumber could be sold at very high prices of up to $200 per thousand feet. It was also believed that the Mexicans, who had won independence from Spain in 1822, would welcome the development of the northern forests, since it could hinder the southward expansion of the Russians as well as provide a source of wood products.

The Mexican market never developed. Because of the lack of currency in the California area, all transactions there were based on barter. The only barterable goods the residents had in abundance were cattle products: hides and tallow. There was no demand for these "California bank notes" in the northwest, so this part of the Hudson's Bay Company trade plan did not develop as hoped (Ficken 1987:14).

The lumber market in Hawaii flourished, however, and the islands became the first major destination for exported lumber. Since its discovery by Captain Cook, Hawaii had developed into an important stopping point for ships engaged in transpacific voyages and a considerable community of Europeans settled there. By the 1820s, the local lumber supply became inadequate to the demand caused by the influx of merchants, missionaries, and sailors. The Hudson's Bay Company found such a ready market that by the early 1840s, lumber products were the islands' chief import (Cox 1974:12). After unloading their lumber cargoes, Hudson's Bay Company ships returned to the northwest laden with cargoes of "sugar, molasses, and fresh produce". With a steady export market in Hawaii, the Hudson's Bay Company became the largest producer of lumber products on the west coast (Ficken 1987:14-15).

By the early 1830s, the Hudson's Bay Company had plans to expand its lumber operations into the Puget Sound area. In 1833, a trading post was established in southern Puget Sound and the exploration of the Sound was begun in order to find locations with good stands of timber near suitable harbors. British efforts to develop the resources of the northwest coast ended, however, when the pressure brought by American settlers and the U.S. government forced them to cede all territory south of the 49th parallel in 1845 (Ficken 1987:16-18).

2.3 The Post Gold Rush Economy

Until 1849, the Pacific coast remained much as it had during the eighteenth century. Furs, whales, cowhides and lumber attracted merchant sailors to the region, but their numbers remained relatively small. The discovery of gold at Sutter's Mill in 1848 changed the nature of the Pacific coast economy for all time. The influx of people seeking their fortunes created a great and sudden demand for products ranging from foods and lumber to luxury items. As a result, the regional economy boomed. Population growth and rising demands greatly outpaced the production capacity of the region, thus the majority of consumer goods had to be shipped from the East coast or from across the Pacific. A massive increase in maritime commerce ensued. A thorough and valuable historical treatment of the California gold rush from a maritime perspective is Delgado's (1990) book, *To California by Sea: A Maritime History of the California Goldrush*.

Literally every available vessel that could be made seaworthy converged upon California between 1848 and 1852. In 1849 alone, 775 ships left eastern harbors for San Francisco. Among these ships were 242 full-rigged sailing ships, 218 barks, 170 brigs, 133 schooners, and 12 steamers. Twenty-four of these ships arrived over a two-week period in September of 1849 (Fairburn 1945:1500, 1802). By November of that year, 500 ships lay abandoned in San Francisco harbor after their passengers and crews rushed to the gold fields.

The most important cargo that the gold rush fleet carried to California was its passengers. Once the gold rush had subsided, these same people provided new markets for consumer goods within the region. Prior to the gold rush the primary market areas for Pacific coast products had been overseas and on the eastern coast of the United States. The gold rush gave the Pacific coast the economic and population boosts that transformed the region from a frontier to a nearly self-sufficient economy.

The boom days of the gold rush did not last beyond the early 1850s, but during that short heyday, the isolation of the Pacific coast was broken. San Francisco was established as the major commercial city west of the Mississippi River. The post-gold rush economy of the Pacific coast continued to be largely maritime-based. The whaling ports of California continued to grow in importance throughout the latter half of the nineteenth century, as the whaling status of New Bedford began to decline. Although the American shipping industry went into a depression during the latter part of the 1850s that lasted through the Civil War, the maritime economy of the Pacific coast emerged from the war in better condition than the United States merchant marine as a whole (Fairburn 1945:951). Both grain and lumber products became major worldwide export items from the Pacific coast during the latter half of the century.

2.3.1 Growth of the Lumber Industry

Like all aspects of life on the Pacific coast, the lumber business was also transformed by the discovery of gold at Sutter's Mill in 1848. As thousands of hopeful miners swarmed into California in search of wealth, even the most commonplace items took on new value and wood products were no exception. San Francisco was bursting with new arrivals in need of shelter, the miners needed wood for their diggings, and building materials of all sorts were in short supply, when available at all. Although there was certainly no shortage of standing timber, lumber production capacity was completely overwhelmed by the sudden demand. The existing mills and sawpits could not produce enough, transportation was inadequate to move large amounts of finished lumber to market, and, like practically everyone else, many lumbermen left their jobs and headed for the gold fields (Cox 1974:46-47; Ficken 1987:21-23).

Instantaneous wealth belonged to but a few, and as the gold fever burned out, some of the disappointed returned to the east while others drifted back to their old jobs or found new ones. Many of the most successful of these turned to the lucrative business of supplying the needs of the miners and the growing towns of California. As the demand for lumber products skyrocketed, those who were able to supply it reaped great profits. Two of these men were Andrew J. Pope and William C. Talbot. The two opened Pope and Talbot's lumberyard in San Francisco and with lumber prices rising as high as $600 per thousand feet at the height of the rush, were able to make considerable profits. Pope and Talbot were not the only ones to take advantage of these opportunities, but they are a noteworthy case because the company they founded is the only one of the early lumber companies still in existence.

As the demand for their products continued to grow, the San Francisco lumbermen began to see the northwestern forest as their business' best source of supply. Because of the difficulty of the coastline north of California, the calm waters and abundant timber supplies of Puget Sound drew the first American lumbermen to the northwest coast in large numbers, just as it had the British (Ficken 1987:21-39).

The remoteness and rugged nature of the forests of the Pacific Northwest made the early years of the lumber industry very difficult. Sawmills had to be located next to rivers which both powered their machinery and served as the only means by which timber could be delivered to the outside world. The great size of the trees themselves created problems. The early mechanical saws could not handle many of the large trees that were being cut down. Even though many ingenious tools were built, such as multiple-bladed circular saws, they were very wasteful of wood and not very sturdy. It was not until the introduction of steam power into the forest in the latter half of the nineteenth century that loggers were able to exploit the forest to its fullest extent. Large steam-driven bandsaws made it possible to cut the largest logs into planks and, equally significant, the steam donkey engine opened more extensive tracts to logging by providing loggers with an improved means of moving felled trees overland for fairly long distances. As the loggers were freed of the technical constraints which for years had limited their output, timber production went ahead at a pace never before imagined (Cox 1974:227-37).

As the California Gold Rush played itself out, the production capacity of the many mills and sawpits which had sprung up to supply that great demand so outstripped the reduced need that new markets had to be found. This expanded lumber industry was bolstered in the three decades following the gold rush both by the needs of the steadily growing Pacific coast population and by a number of spot markets which consumed large amounts of lumber products, including an Australian gold rush in the 1850s, and massive railroad projects in the U.S. and South America throughout the latter-half of the nineteenth century (Cox 1974:97, 139).

Lumber continued to be a major Pacific coast export after the Civil War. International shipping of lumber was based out of San Francisco and Puget Sound, the latter of which was beginning to realize its potential as a lumber-producing region. Much of the lumber shipped internationally was sent to the Pacific islands, Australia, and South Africa. A large amount was also sent to South America. Many of the ships sailing from Puget Sound returned with cargoes of coal from Newcastle (Fairburn 1945-1955:2702-03).

2.3.2 The Grain Trade

The development of the Pacific coast agricultural economy followed from the major influx of settlers into the region during the gold rush. Once the flurry of gold digging had subsided, many immigrants began experimenting with agriculture on the large tracts of arable land in the Sacramento and San Joaquin river valleys. By the mid-1860s, a large number of settlers had also begun wheat farming in the interior of Oregon, having moved there in search of gold during the late-1850s. Wheat production in Oregon was greatly stimulated in 1867 by news that 1,000 barrels of flour had been successfully shipped to San Francisco for a profit. Within a year, Oregon had entered the international grain trade when its first load of transpacific wheat left Portland for Liverpool aboard a British ship (Meinig 1954; Paul 1958).

By 1873 there were 136 American-built square-riggers in the California grain trade alone, as well as a number of foreign vessels, mostly British. Two years later there were 265 vessels (including only 62 American vessels) exporting grain from California. By 1881-82 this number had more than doubled to 559 vessels (including 154 American vessels). Meanwhile, the Oregon grain trade grew steadily after the first transpacific shipment left Portland in 1868. In 1870, five ships sailed from Portland with transpacific wheat cargos. By the 1879-80 season the number of shipments had increased to 81 (Meinig 1954:17).

Oregon wheat exports were never as large as those from California. In 1884, for example, Oregon's exports (5,500,000 bushels) comprised only one-sixth of the total coming from the Pacific coast. Most of the balance came out of the Sacramento and San Joaquin river valleys by way of San Francisco Bay. "A fleet equal to that calling at Portland loaded at each of the four important wheat ports [Port Costa, San Francisco, Vallejo, and Benecia] in the Bay area" (Meinig 1954:18). The combined wheat exports from California and Oregon accounted for one-half of all wheat exports from the United States by 1885.

The role of American shipping in the transpacific grain trade decreased significantly over the 1870s and 1880s, as British ships carried more and more Pacific coast wheat. The 1882 harvest was a record. Of the 559 vessels that sailed from Pacific coast ports in that year, however, only 154 were American. During the decade from 1882-1892, an average of 214 British vessels were active in the California grain trade annually. Over the same decade, American involvement decreased to a low of 39 vessels by 1892 (Fairburn 1945:2629-2631). Meinig (1954:18) estimated the size of the multi-national Pacific coast grain fleet during the mid-1880s at 700 vessels.

The majority of British ships carrying grain by this late date were iron-hulled vessels, while the Americans were primarily sailing wooden-hulled Down Easters. The Down Easters were faster than iron, due to the rapid fouling characteristic of nineteenth-century iron hulls, and offered cheaper freight rates. Nevertheless, by the early 1890s the role of American-built vessels in the grain trade had been almost completely usurped by the British (Fairburn 1945:2635).

2.3.3 Pacific Coast Shipbuilding

Shipbuilding was not a major industry in the study area until well into the nineteenth century. Many of the earliest ships to sail along the Pacific coast, including the Manila galleons, were built by the Spanish along the coast of what is now Mexico. The Spanish had shipyards in La Navidad, Acapulco and Zihuatanejo. Some of the later Manila galleons were constructed at Cavite in Manila Bay (Almazan 1971:20). Except for the miscellaneous repairs required on long voyages, the early explorers of the Pacific coast did not utilize the timber resources of the Pacific Northwest for shipbuilding.

2.3.3.1 Merchant Sailing Vessels

The first wooden sailing vessel known to have been constructed in the study area was the small schooner *Dolly*, launched at Astoria, Oregon in 1811. The *Dolly*, however, was built largely from parts brought from the east coast aboard Astor's ship *Tonquin*. Use of local materials in wooden ship construction was not common until after the gold rush. The excitement of the gold rush economy, however, did prompt farmers living near Astoria to build the two-masted schooner, *Skipanon*, to carry produce south to San Francisco (MacNairn and MacMullen 1945:11). For the most part, the gold rush resulted in a great overabundance of eastern-built wooden sailing vessels on the Pacific coast, abandoned by their gold-digging crews.

In spite of abundant lumber supplies in the region, wooden shipbuilding never became as important of an industry on the west coast as it was in the East. Oregon pine (Douglas fir) was useful as deck planking and spars but was not a good substitute for the harder woods, such as live oak, white oak and southern pine, used for framing and hull planking in the shipyards of the eastern states. Prospective shipbuilders faced other problems besides the quality of wood. The cost of labor to build vessels on the Pacific coast was so prohibitive that many owners chose to purchase a used and tested oak-built ship from the east coast rather than to run the risks and expense of building a new ship of west coast pine (Fairburn 1945:2605).

In the early 1870s, shipwrights learned that Oregon pine could be made more suitable for shipbuilding if it was cut during the winter and carefully seasoned and salted. Wood treated in this manner was made durable enough that fairly large ships began to be produced at west coast shipyards. In 1871, for example, the 1,100-ton *Wildwood* became the first large vessel to be built entirely out of local wood on the Pacific coast of the United States.

During the years 1864-1884, a comparatively small number of sailing vessels were built in west coast shipyards. According to Fairburn (1945), 85,711 tons of shipping were constructed during this twenty-year period. The yearly average of 3,571 tons is somewhat misleading, however, as 10,000 tons were built during the most productive year (1882) while other years saw less than 1,000 tons launched. Most of the vessels that were built during this period were schooners, barkentines, and a few barks in the 300- to 500-ton range. Very few wooden square-riggers were ever built on the Pacific coast.

Fairburn considered the *Wildwood*, *Western Shore* and *Cassandra Adams* to be representative of the best square-rigged ships built on the west coast. The *Cassandra Adams* was launched at San Francisco in 1876. The vessel was almost 197 ft long, displaced 1,083 tons, and had the lines of a medium clipper. She was used for four years to carry lumber in the Pacific coast trade before being transferred to the Cape Horn route. Her best run westward from New York to San Francisco was 107 days, covering the same distance eastward in 94 days. Considering that the record time for an extreme clipper in this run was 89 days, the speed of the *Cassandra Adams* is quite respectable. The *Cassandra Adams* was pulled from the Cape Horn run in 1885 and ended her days back in the lumber trade. She was lost off of Destruction Island in August of 1888.

In the early 1890s, production of wooden sailing vessels in the Puget Sound area increased. Shipyards there produced schooners and barkentines, displacing between 800 and 1,600 tons for both coastwise and transpacific lumber trade. Between 1890 and 1900, 49 schooners (all four-masted except for one with five masts) and 9 four-masted barkentines were launched. Over the decade following 1900 this number increased. Between 1901 and 1910, 73 four-masted and 4 five-masted schooners were launched as were 15 four-masted barkentines. Most of the vessels built during the latter decade were below 1,300 tons displacement.

The northwest coast wooden shipbuilding industry disappeared almost entirely after 1910. The shipyards were not able to compete on the levels of pricing or quality with the large shipyards in Maine for new vessels, as older hulls could be purchased less expensively than new ones from either source. From 1910-1915 the Pacific Northwest shipyards did not build any vessels. The shipping demand caused by World War I, however, brought the wooden shipbuilding industry back to life for a short period. Between 1916 and 1919, 125 schooners and barkentines were built as part of the war effort. These last wooden vessels were mostly schooners ranging in size from 1,000 to 2,700 tons. There were no square-riggers produced during this final surge of wooden shipbuilding. The completion of the last vessel in 1919, marked the end of wooden shipbuilding in the Pacific Northwest (Fairburn 1945:2605-2607).

2.3.3.2 Steam Vessels

Prior to 1850, the Pacific coast lacked industrial facilities capable of producing steam engines or iron hulls. One of the earliest industrial developments on the Pacific coast was the establishment of the Pacific Mail Steamship Company's depot and iron foundry at Benecia in the upper reaches of San Francisco Bay. The Benecia foundry, constructed in 1851-1852, was capable of repairing the largest steam machinery and boilers used on the Pacific Mail steamers (Delgado 1990:132-139). Pacific Mail was fairly self-sufficient as a result, although competition was developing simultaneously across the bay in San Francisco.

During the 1850s, a sizeable industrial district developed at San Francisco's Happy Valley. "By the spring of 1850...numerous foundries were erected there. These included the Union Iron Works (which later would boom into the state's major ironworks and iron and steel shipbuilding firm), the Vulcan Iron Works, the Sutter Iron Works, the Alta Foundry, and the Pacific Iron Works" (Delgado 1990:140-141).

In addition to the new iron foundries locating in San Francisco, the number of firms involved in shipbuilding was increasing rapidly during the early 1850s. The number of San Francisco residents that listed themselves as professionals in the shipbuilding industry increased from four in 1850, including "a shipwright, a ship carpenter, a caulker and a boilmaker" to 56 in 1851, "including one 'ship builder,' a marine surveyor, six shipwrights, twenty-two ship carpenters, nine caulkers, nine ship joiners, six ship smiths, and two blockmakers" (Delgado 1990:141).

The shipbuilding and ship repair industry was given a boost when the U.S. Navy purchased what was to become the Mare Island Naval Yard in 1853. This was to be the base for the Navy's Pacific fleet. The Navy soon opened the first dry dock on the Pacific coast at Mare Island, assembled from pieces that had been shipped around Cape Horn in 1852. This dry dock was also leased to private merchants for hull repairs.

The first Pacific-built steamers were reportedly built from preassembled pieces at San Francisco Bay in 1849-1850. By 1850-1851 steamers were being constructed from primarily local materials. Most early steamers were built of wood; although, in 1851 a 65-ft iron-hulled scow was constructed at Egery and Hinckley's foundry in San Francisco (Delgado 1990:141). The first steamer to be constructed at Mare Island was the warship *Saginaw*, launched in 1859.

2.3.4 *Twentieth-Century Commerce*

Logs and lumber were the major export items from the Pacific coast during the first four decades of the twentieth century. Grain and flour remained significant exports through 1930, but declined sharply during the years of the Great Depression and stayed low through at least 1938. Other leading commodities during the early twentieth century included petroleum and its byproducts which steadily increased from 1922 to 1930. Scrap metal replaced grain as one of the four leading export commodities in 1936 (Radius 1944:32-34).

2.4 Ships and Shipwrecks on the Pacific Coast

A great variety of ships have wrecked along the Pacific coast since the days of the earliest explorers. The earliest known shipwreck to have occurred in the study area is that of the Manila galleon *San Agustin*, lost in Drakes Bay in 1595. Since that time, literally thousands of vessels of many types and descriptions have wrecked along the Pacific coast and in the study area. An integral part of this study entailed the compilation of a database listing shipwrecks that occurred in the study area prior to the end of World War II. The types of vessels most characteristic of the Pacific coast, and of the shipwreck database, during the study period are discussed below in Section 2.4.1. Subsequently, summary statistics regarding the shipwreck population of the Pacific coast and study area, as represented in the database, are discussed in Section 2.4.2. The latter includes a summary of shipwreck frequency through time, by geographic area, and by vessel type.

2.4.1 *Vessel Types and Designs*

The classification of marine vessels by type during the database compilation presented a problem, since historic records are not consistent in the classification system used. For example, sailing vessels are commonly referred to by names, such as bark, brig, ship or schooner, that indicate the number of masts and/or the style of sail rigging. Classification according to rigging says nothing about hull design or construction material but at least it is consistent. Steamers are typically classified according to the type of propulsion mechanism used, for example, sidewheel, sternwheel or propellor (the latter is commonly referred to as a screw).

Problems arise when terms such as clipper, packet, freighter or liner are mixed with those referring to rigging. Since such terms find common usage in maritime history, a mixed system of vessel classification has unavoidably been used in the shipwreck database. Appendix G contains a listing of vessel types and their abbreviations used in the database.

As a preface to the discussion of vessel types represented in the database and their frequency of loss along the Pacific coast, background information is provided regarding the definitions, chronology and history of the vessel types most common to the region. The emphasis here is primarily on larger merchant vessels, as the database is unavoidably biased toward those classes of vessels. While small vernacular watercraft (unique regional styles) are, no doubt, abundantly represented in the archaeological record of the study area, they are admittedly underrepresented in the database. This is due to the facts that their losses were not generally newsworthy and that they often were not registered with any government institution that would leave a record of their existence.

The following definitions for common merchant vessel "types" are from Layton's (1987) *Dictionary of Nautical Words and Terms*:

> **Barque** [also Bark]. Sailing vessel with three or more masts: fore and aft rigged on aftermast, square rigged on all others.
>
> **Barquentine** [also Barkentine]. Sailing vessel with three or more masts. Square rigged on foremast, fore and aft rigged on all others.
>
> **Brig**. Vessel with two masts and square rigged on both of them.
>
> **Brigantine**. ...Up to end of nineteenth century was a two-masted vessel square rigged on foremast and main topmast, but with fore and aft mainsail. Latterly, a two-masted vessel with foremast square rigged, and mainmast fore and aft rigged.
>
> **Clipper**. Name applied to fast sailing ships, particularly--at first--to the sharp-lined, raking schooners of U.S.A. Hall mark of a clipper is generally taken to be a fine entrance with a concave bow.
>
> **Packet**. Mail vessel that may also carry passengers and cargo. Sometimes applied to a passenger vessel on a regular run.
>
> **Schooner**. Fore and aft rigged vessel having two or more masts.
>
> **Scow**. Flat-bottomed, square-ended craft used for transport of cargo.
>
> **Ship**. ...Technically, a sailing vessel having three or more masts with yards crossed on all of them.
>
> **Sloop**. One-masted sailing vessel having fore and aft rig, bowsprit, and jib stay. Name is often given to any such vessel having a single-head sail (Layton 1987).

The first vessels known to have sailed along the Pacific coast were built by the Spanish in their New Spain shipyard at Tehuantepec (Wagner 1966:5). Unfortunately, little is known about the construction and outfitting of these vessels. The ships of the first explorers, such as Mendoza and Bertandona, were the first built on the Pacific coast and were probably not a great departure from the styles of contemporary Spanish shipbuilding elsewhere. They were likely built with lines similar to those of Spanish barcas or caravels (Palacio 1587:113-139).

Beginning in the 1560s, Manila galleons became the second type of European vessels which regularly sailed Pacific coast waters. The era of the Manila galleon lasted for over two centuries (Almazan 1971:20-34). These vessels carried goods from the orient west across the Pacific to the New World for transhipment to Europe. The earliest Manila galleons likely resembled Spanish *naos*. Although the design of the *naos* is not well-known, scanty hull remains from one archaeological example along the Texas coast, the 1554 wreck of *San Esteban*, indicate a wide-bottomed vessel between 20 and 30 meters (m) long with a displacement between 164 and

286 tons (Arnold and Weddle 1978:218; Doran and Doran 1978:365-384; Baker 1978:385-389; Smith 1988:89). During the long period that this trade existed, these galleons evolved considerably from enlarged versions of *naos*, similar to the *San Esteban*, into the widely recognized style of heavily armed vessels with high-sides and tall stern- and forecastles, and finally into the sleeker, better-sailing *galeoncetes* (Smith 1988:91).

Manila galleons remained relatively small until the eighteenth century. Phillip II of Spain had decreed during the 1550s that only two 300-ton galleons per year could sail to Manilla from New Spain. In 1720, the tonnage limit was raised to 560 tons, although these limits were often exceeded. The galleon *Rosario* (1746-1751), for example, was a 1,700-ton vessel, and the *Santisima Trinidad*, captured by the British in 1762, had a 2,000-ton displacement and was the pride of the Spanish merchant fleet (Almazan 1971:28).

Although Spanish vessels changed considerably in design over the years, one common feature of most was their emphasis on being heavily armed. Ship's artillery has provided the most readily identifiable remains of early sixteenth-century wrecks in the New World. Almazan (1971:29) states that Manila galleons were not, however, heavily armed until piracy by the English, Dutch and French became a problem, beginning in the last quarter of the sixteenth century. Most Manila galleons wrecked along the Pacific coast will undoubtedly have a large number of guns as a primary diagnostic feature.

Due to the hiatus in Spanish voyages of exploration during the seventeenth and eighteenth centuries, Manila galleons were the only sailing vessels visiting the west coast on a regular basis until the explorers and hunters of other countries began to arrive in the late 1700s. With the beginning of the fur trade, however, European vessels became a common sight along the Pacific coast. Between 1787 and 1826, for example, 127 fur trading voyages were made to China from the Pacific coast of America (Vaughn 1976:86). According to William Sturgis, most of the ships used along the Pacific Coast during the fur trade were between 100 and 250 tons burden. These were square-rigged vessels, equipped for voyages lasting several years and usually involving a circumnavigation (Vaughn 1982:3; Fairburn 1945:509). Like the vessels of the explorers before them, these trading ships were usually well-armed.

William Armstrong Fairburn, in his landmark 1945 publication *Merchant Sail*, detailed the history of American sailing ships and maritime commerce. Fairburn singled out four large groups of deep ocean sailing vessels in the American merchant marine that won particular distinction for their role in history. In chronological order of their popularity, these are the whaler, packet, clipper and Down Easter (Fairburn 1945:1080). With the exception of the whaler, these were cargo carriers, generally hauling whatever freight was most profitable, including passengers. During the first half of the nineteenth century, packets were the work horse of the American merchant marine. During the 1850s, clipper ships had a relatively brief, though spectacular career as a direct result of the California gold rush. In the latter half of the nineteenth century, especially after the Civil War, American deep ocean trade was dominated by the Down Easters, so named because they were built "down east" in Maine.

The "golden era of whaling" in the Pacific began around 1829 and continued as an industry throughout much of the century. By the mid-1870s, however, the volume of whale oil taken annually by the American fleet was in rapid decline (Fairburn 1945:1011). Whaling vessels were typically rigged as barks or square-riggers (i.e., ships). A large number of whalers from the 1820s through the 1850s were old sailing packets that had been converted (Fairburn 1945:1004). "After 1855 a number of medium-clippers [i.e., having medium-sharp hull lines by comparison with an extreme clipper ship] were built particularly for the business, usually barque-rigged. These vessels were sharp-floored and easy-bilged to make them roll down when 'cutting-out' a whale" (Chapelle 1935:288).

In 1829 there were 203 whalers in the U.S. fleet. This was approximately one-tenth of the entire American fleet at the time. By 1840 this number had risen to 554 vessels. Ninety four percent of the fleet in 1840 was comprised of ships and barks. The balance were brigs and schooners. The fleet reached its peak size in 1858. Not surprisely, this was also the year of the largest catch (198,594 tons of whale oil). The catch first exceeded 190,000 tons of oil in 1845. The annual average tonnage for the period 1845-1859 was 186,436 tons (Fairburn 1945:1002-1011).

The drilling of the first oil well in 1859 at Titusville, Pennsylvania signalled the decline of whaling. Petroleum products soon appeared on the market to replace whale oil as lubricants and illuminants at cheaper prices. The decline of whaling, although inevitable due to overhunting and competition with petroleum, was hastened by the Civil War. In 1862 whale oil production was down to 117,714 tons; in 1868 only 78,486 tons were taken; and by 1876, the total catch came to only 39,116 tons (Fairburn 1945:1011).

Following the War of 1812, increased "packet" trade with Europe created a demand for larger and faster ships. "During the early years of the packet trade there was little improvement in model, but the short voyage and the possible increase and regularity of passages turned the packet-owners' attention toward an increase of speed. By 1825 a new class of packet had been evolved... Gradually the type became increasingly distinctive and reached its height about 1840-5..." (Chapelle 1935:277).

From the early 1820s through the 1840s, packets were the dominant trading ship of the American merchant fleet and were especially popular in the Atlantic trade with Europe. These were primarily square-rigged ships. Fairburn described the design of their hull as:

> ...beamy and rather full forward, but had good water lines aft and...a bottom sloping well up from the keel. She was generally high out of water at the bow and had a good flare forward, with a short, buoyant overhang and moderate freeboard aft. The masts were sloped aft more than was usual, and much sail was carried, giving a rather low and rakish appearance (1945:1498).

According to Fairburn (1945:1656) the era of the sailing packets ended in the 1850s, although much of their design charasteristics lived on in the medium clippers of that decade and in the Down Easters of the 1860s-1880s.

The clipper ship was, without a doubt, the fastest design ever to sail in the American merchant fleet. But this speed was attained at the sacrifice of carrying capacity and hull strength. Chapelle (1935:284) decribed the clipper ship's development as a culmination of the "mania for speed [which] had slowly been infecting American seamen and shipbuilders since 1790." The desire for sailing speed was not unique to the period of the California and Australia gold rushes; however, the added impetus of these profitable markets caused speed to be placed ahead of cargo capacity. High profits associated with the gold rush boom economy, in combination with the highly publicized and romantized spirit of competition for fast passage, allowed the clipper ship to continue in popularity longer than economics alone would have dictated. Chapelle attributed the clipper ship's short career (approximately 1846-1859) to its relatively low carrying capacity and extremely high operating costs. In addition to trading off cargo capacity for speed, "the hard driving, necessary to get speed out of these ships, required large crews and, also, caused loss of spars, sails and gear, as well as straining the weakly built wooden hulls" (Chapelle 1935:286).

Clipper ships were most popular in the New York to California route and in the China trade. Their design kept them from competing in the transatlantic trade. Not only did they have comparatively weak hulls, but they tended to ship a lot of water in heavy seas, both undesireable characteristics from the perspective of cargo and passengers in the North Atlantic. "...the clipper concave water-line bow, with but little flare above, cut the water sharply and did not have much buoyancy or lift forward, whereas the packet bow had convex forward water lines of pronounced fullness and a flare with buoyance above, so that the ship rose to the sea instead of plunging through it" (Fairburn 1945:1082).

Following the gold rush, the demand for large numbers of extreme clipper ships decreased. The high-profit margins of the early 1850s were gone. Their owners were forced to seek any cargo to keep their vessels employed. Fairburn wrote with sorrow that American clippers "had degenerated into the carrying of 'filthy, stinking' guano from Peruvian ports... and the vile dirt, dust, and smell from this 'worst of all cargoes' permeated the ship that carried it" (1945:42).

During the 1850s a number of clippers were constructed that had broader beams and fuller ends than the extreme clippers. These medium clippers (Figure IV-3) were "revivals of the last and sharpest of the packet-ship models; with the addition of the plain, unadorned bow and counter of the clipper. The medium-clippers were larger and better built than the earlier packets, and also had many of the improved fittings on deck and aloft that had been developed in the clippers" (Chapelle 1935:287). According to Howe and Matthews (1926), at least 121 medium clippers were constructed prior to 1858.

A number of factors contributed toward the demise of the clipper ships. Competition from steamers via the isthmus of Panama, especially after the completion of a railroad across the isthmus in 1855, was a major factor in the decline of the New York to California route around Cape Horn. The economic depression of the late 1850s combined with the Civil War stagnated American shipping in general. Economic hard times were likely the impetus for a gradual shift away from the speed of square-rigged ships during the late 1850s-1870s in favor of the slower but more economical bark and barkentine riggings (Fairburn 1945:1654). The completion of the transcontinental railroad finally made extreme speed of sail unaffordable for all time. In order to remain competitive with steam in the years following the war, wooden sailing vessels were designed with an emphasis on economy. The result was the Down Easter, "...without doubt, the highest development of the sailing ship; combining speed, handiness, cargo capacity and low operating costs to a degree never obtained in any earlier square-rigger" (Chapelle 1935:287).

The design of the Down Easter was not something altogether new to wooden sailing ships, rather it combined several familiar characteristics of the 1840s packet and the Maine-built medium clipper of the 1850s.

> It is not true that "the death of the clipper was the birth of the Down Easter"...the real birth of the Down Easter was in Maine during the closing years of the eighteenth century. The Down Easter merely grew with the years and developed as a type and in size, so that when the clipper failed as a money-making trader, the Down Easter was available to take its place... (Fairburn 1945:1651).

The Down Easter became famous after the Civil War and formed the backbone of America's deepsea merchant sailing fleet for the remainder of the century. The most prosperous years for the Down Easter design were the 1870s and 1880s. Fairburn singles out 1884 and the construction of the *Henry B. Hyde* as the zenith of quality in this line of ships. "This full-rigged ship, as well as a large fleet built in the seventies and eighties that closely resembled her, illustrates

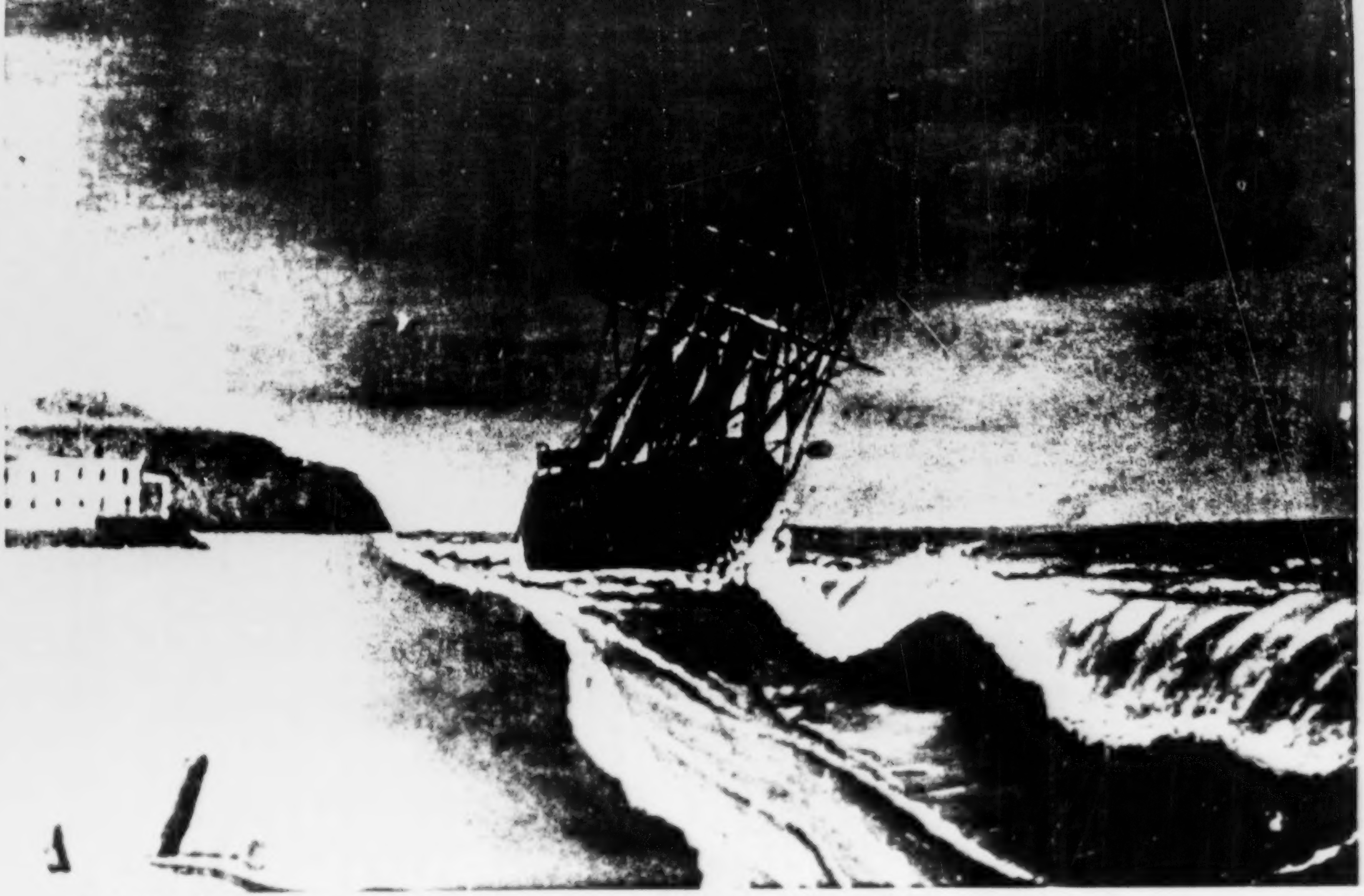

Figure IV-3. Painting of the Medium Clipper *King Philip* Aground at San Francisco, 1878 (photo courtesy of National Maritime Museum, San Francisco, California).

a type that was neither clipper nor packet in any respect and was similar to no other class of vessel built in any other part of the world. The Down Easter stands on the pages of history as America's supreme effort in the realm of wood sail" (Fairburn 1945:1651). The last of the great wooden square-riggers was built in 1893 (Fairburn 1945:1656).

Whaling and the deep-sea trade played a significant role in the economic development of the Pacific coast; however, in the process of this growth, the domestic economy also spread rapidly up and down the coast. A coasting fleet of merchantmen, dominated by two- and three-masted schooners, developed in support of both international and domestic trade. Throughout the latter half of the nineteenth century, most bulk cargo, including lumber and wheat, was exported from San Francisco and Portland. Since wheat was produced inland, transportation to port for transpacific shipment was primarily overland. Timber, on the other hand, was generally moved downstream to small harbors known as "dog-holes" where it was loaded on schooners (Figure IV-4), as lumber, for shipment to major ports such as San Francisco. From San Francisco's warehouses, lumber destined for international markets was loaded on deepsea trading vessels.

Schooners were uniquely North American in their development. Fairburn (1945:2608) credits Maine shipbuilders with the idea of adding a second mast to the fore-and-aft-rigged sloop to create the schooner. "The most rapid development of the schooner took place after the appearance of the sharp-lined hull, later known as the 'Baltimore Clipper'," as early as 1746 (Chapelle 1935:221). By the early nineteenth century, the schooner had spread throughout the United States and was carrying the majority of America's maritime cargo. From 1815 through 1859 schooners consistently outnumbered all other classes of merchant sailing vessels (Fairburn 1945:1530-31). The popularity of schooners continued to increase throughout the latter half of the nineteenth century until reaching the peak period of American schooner construction between 1900 and 1904.

The popularity of schooners in the Pacific coastwise trade was due to a combination of economy and handling characteristics. It took one half the crew to operate a schooner that was required to sail a brig or brigantine of comparable size. Smaller crews meant larger profits. As a result, coasting brigs and brigantines were largely replaced by the more economical schooners during the latter half of the century (Fairburn 1945:1654). Surprisingly, as Fairburn points out, the large American coastal packet lines operated only full-rigged ships (not even any barks) despite the economy of the schooner rig.

The schooner, being typically smaller and shallower draft than deepsea traders, was also able to maneuver in narrow channels and small "dog-hole" harbors more safely than could larger, full-rigged ships. Hence the name "dog-hole schooner" became popular (Jackson 1969). In order to cross shallow harbor bars, many schooners were equipped with retractable centerboards to give them a shallower draft. Dog-hole schooners were made even more capable when many began to receive steam engines in the 1880s.

Prior to the 1880s the vast majority of schooners sailing along the Pacific coast were two- or three-masted vessels. During the period from about 1880 to 1909, builders began to produce larger and larger schooners. Four-masted schooners first appeared in the 1880s, followed by five-masted schooners in the 1890s and in the first decade of the twentieth century by incredibly large six-masted (and even one seven-masted) vessels (Fairburn 1945:1654; Cox 1974:244-254). The increase in size was largely a response to stiff competition with steam tugs towing long lines of barges in the coastwise trade, although the use of schooners and barkentines in the transpacific lumber trade may also have affected the decision to build larger vessels.

> ...the fore-and-aft rig [schooners and barkentines] (so relatively cheap to operate) was particularly effective in the trade wind belts of [the] Pacific

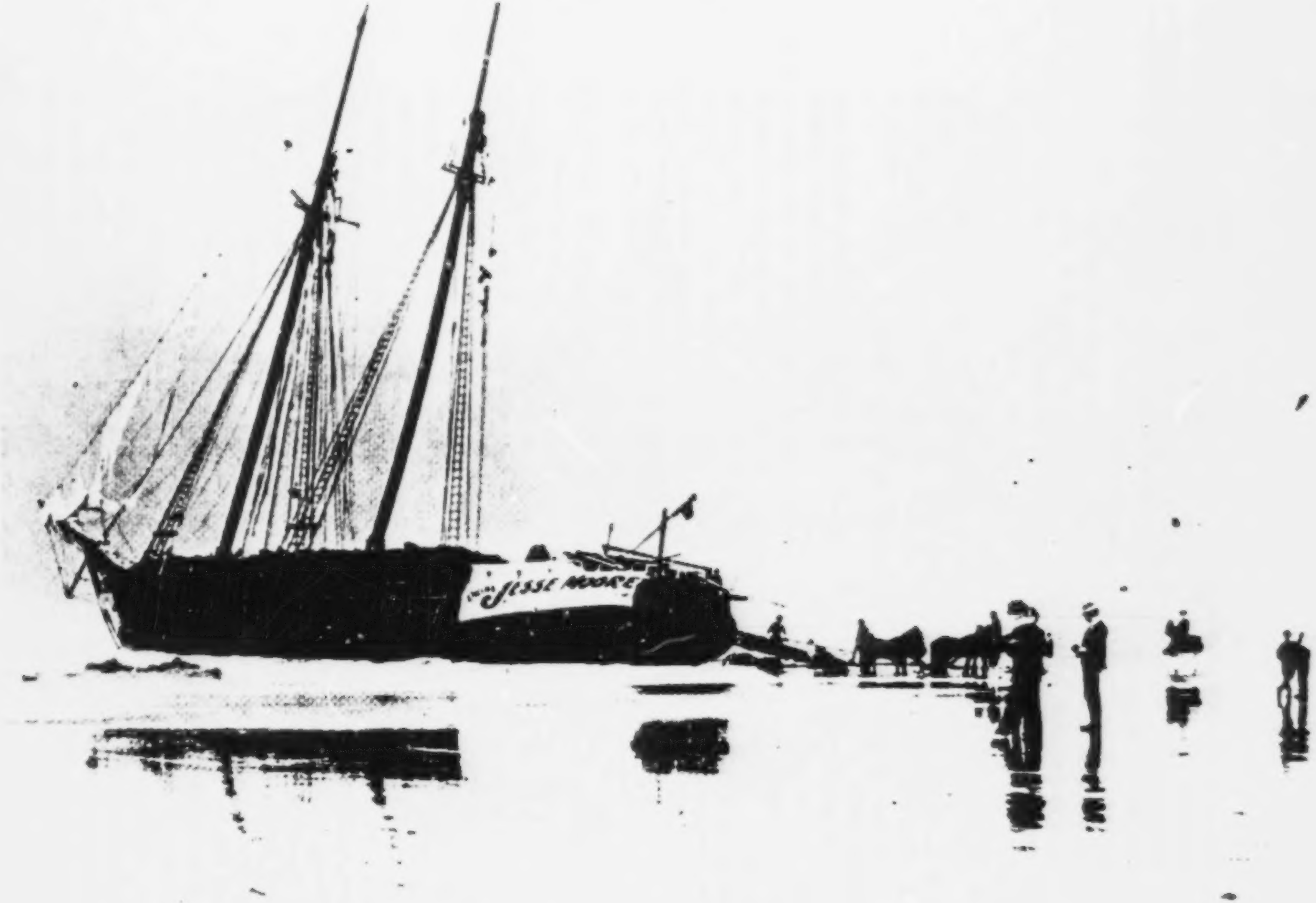

Figure IV-4. Wreck of the Lumber Schooner *Reporter,* 1902 (photo courtesy of National Maritime Museum, San Francisco, California).

> Ocean, where strong beam or head winds are encountered... The barkentine rig on the Pacific, [however] with its yards on the foremast, was soon found to be superior in general sailing to the straight line schooner... The square-rigger was much faster than the schooner on routes in which strong fair winds were encountered and much safer and more reliable... [Although the] Pacific coast fore-and-after was employed in the lumber trade from Puget Sound to Australia and the Orient, ...the barkentine in such runs was superior to the schooner (Fairburn 1945:2607).

The largest schooner ever built was the six-masted *Wyoming* in 1909, measuring 330 ft long by 50 ft abeam and having a 30-ft depth of hold. The *Wyoming* required a crew of only 11 men to sail. After 1909, the number of schooners constructed in the United States went into rapid decline. The last American-built coasting schooner was launched in 1921 (Fairburn 1945:1636;2608-2609).

The development of steam-powered vessels was a long process, lasting through most of the eighteenth century, but by the 1880s, they were major competition for America's wooden sailing fleet. Steamships first sailed along the Pacific coast in the late 1840s. In 1847, Congress had passed the mail steamship service bill. This act authorized the Navy to contract with private companies for the establishment of a steam trade between New York and California via the Isthmus of Panama. "The stated object [of the bill] was 'to aid in populating the Pacific coast and reduce the length of journey' from 175 days by sailing around Cape Horn to an estimated 30 days by steam vessel..." (Fairburn 1945:1360). When the Panama steam route was finally established, it took closer to 40 days, as compared with an all time record of 89 days for a clipper ship sailing around Cape Horn.

The Navy contracted with two separate firms, one for the Atlantic side and one for the Pacific. The Pacific portion of the route was awarded to a New York firm called Howland and Aspinwall which quickly formed the Pacific Mail Steamship Line. By total luck, Pacific Mail was organized on the eve of the California gold rush. Their first steamship, *California*, arrived in San Francisco with nearly 400 passengers on 28 February 1849, just weeks after news of Sutter's Mill had reached the East coast (Tate 1986:21; Fairburn 1945:1363).

Pacific Mail started out with three steamers, *California*, *Panama* and *Oregon*, and were required by contract to make monthly runs between Panama and Astoria, Oregon stopping in San Francisco en route. In exchange for providing this service, Pacific Mail was to receive a government subsidy of $199,000 per year for ten years. Service to Astoria did not commence until 1851; however, in that year Pacific Mail doubled the size of their fleet to include six vessels, increased the service to two runs per month, and, in exchange, began receiving an annual subsidy of $348,250 (Fairburn 1945:1363). Service improved greatly over the Panama route, as a whole, when a railroad was completed across the isthmus in 1855. "...for many long years after the start of the gold rush...all sailings north [from Panama] were made at capacity (both passengers and freight)...It is estimated that, 'in the first ten years, these steamers carried 175,000 persons to California and brought back $200,000,000 in gold'" (Fairburn 1945:1364).

Although the Panama steam route was a great success, transpacific steam trade was slower to develop. China had been open to American trade since 1787. Japan, however, did not open its doors to trade with the United States until 1854. The first steamers to cross the North Pacific after the opening of Japan were the warships *Mississippi* and *Susquehanna* of Commodore Matthew Perry's squadron in 1854 (Figure IV-5). Although a very few merchant steamers made

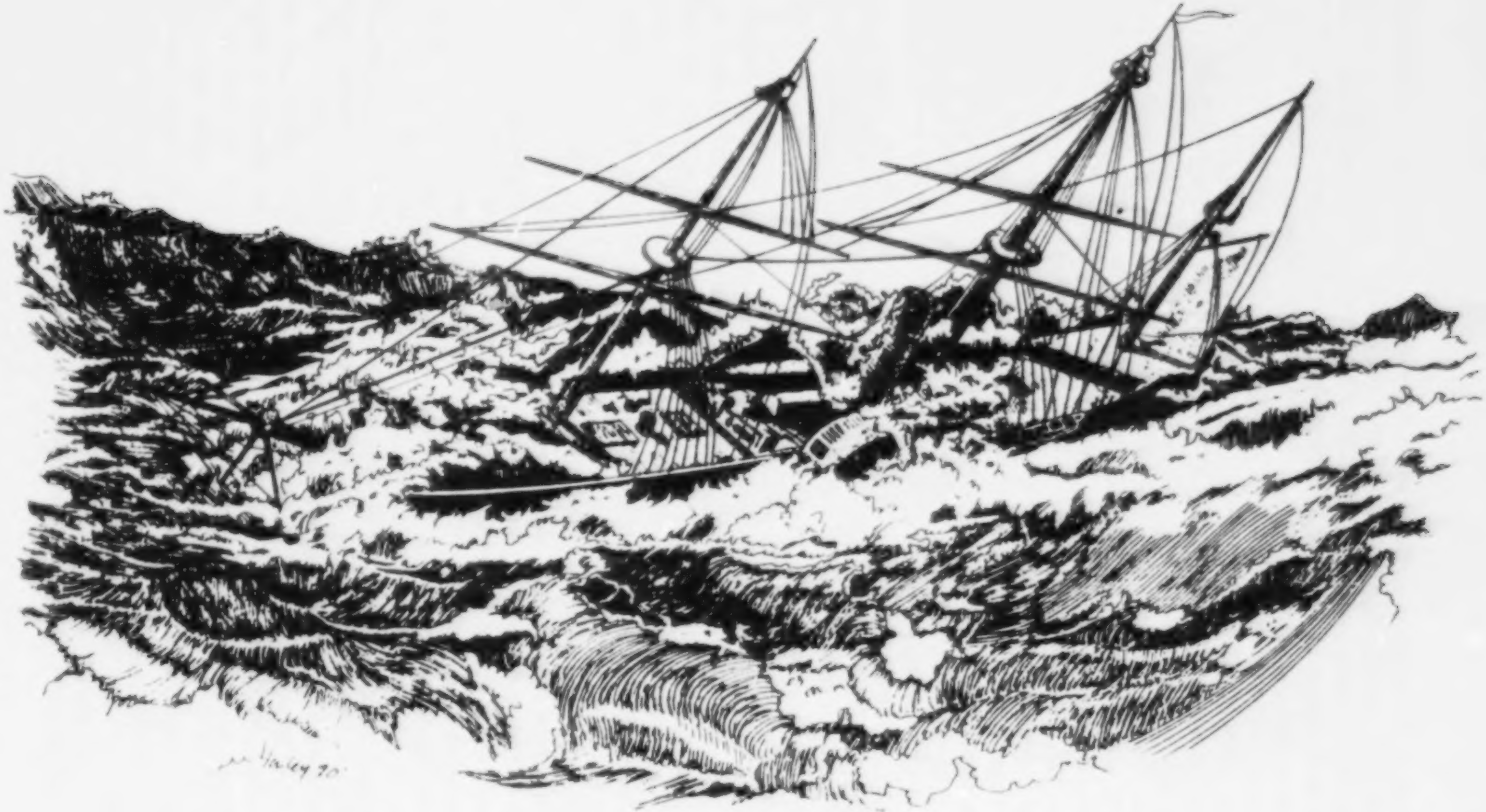

Figure IV-5. The Sidewheel Steamer *Mississippi*, During an 1854 Pacific Crossing (after a work in the Naval Historical Center as published in Tate (1986)).

transpacific runs during the 1850s, most did so under power of sail, as there was no coaling stop on the direct route to China from San Francisco (Tate 1986:21-23).

Following the economic slump of the Civil War, Congress passed legislation in 1865 to encourage the development of a transpacific steamship trade with Japan and China. Again, government subsidies were authorized. Without subsidies, owners and builders would not likely have risked the capital needed to build the required steamers. No doubt wishing to thwart British competition in the Pacific, Congress authorized an annual subsidy of $500,000 in exchange for a monthly service between San Francisco and the Orient via Hawaii. The Pacific Mail Steamship Company was awarded the contract and had four wooden paddlewheel steamers built for the purpose. The first of these, *Great Republic*, made its first run in 1867. By 1871 Pacific Mail had six transpacific steamers in service, four on the direct San Francisco to Yokohama route and two providing monthly service between San Francisco and Honolulu (Fairburn 1945:1392-1393).

The Pacific Mail came under criticism for building these first transpacific steamers of wood and equipping them with paddlewheels at a time when the British, and to a lesser extent the Americans, were increasingly building iron-hulled screws. The British had experimented with the use of iron plates for the external hull of canal boats as early as 1789. The first iron-hulled sailing vessel for use in salt water is believed to have been the *Vulcan*, built by the British in 1818. In 1838, the 271-ton bark *Ironsides*, built in Liverpool, was the first iron sailing ship to be employed in transoceanic trade (Fairburn 1945:1380-1381).

American shipbuilders had been using iron to a very limited extent as early as 1838 (Fairburn 1945:1401). By 1861, 11 out of a total 264 steamers built in the states (including riverboats which continued to use wood throughout their history) had iron hulls. In 1871, 23 iron-hulled steamers were built in America (out of 302 total).

The main reason for Pacific Mail's persistence in using wood was North America's lack of iron foundries that could build a ship of the proportions considered suitable for transpacific trade. Their reason for using paddlewheels rather than propellors was less justified, considering that the efficiency of screw propulsion had been proved superior to paddles by this date[1]. Novelty Iron Works, a major shareholder in Pacific Mail, manufactured the sidewheel machinery used in their steamships (Fairburn 1945:1394).

In 1872 Congress authorized new subsidies to encourage the development of iron screw steamers in the transpacific trade. The new contract, awarded to Pacific Mail, called for duplication of the existing routes to the Orient and Hawaii, except using iron-hulled screws. Owing to the shortage of large foundries in the United States, Pacific Mail leased their first two iron screws from the British in 1873 and began twice monthly transpacific runs. The next year two additional iron screw steamers were leased from the British, and Pacific Mail's first two American built iron screws, *Granada* and *Colima*, were put into service (Fairburn 1945:1395-1397).

The giant wooden transpacific paddlewheelers last sailed in 1879. Coincidently, this was the first year that steam tonnage built in the United States exceeded that of merchant sailing vessels. This was nearly a decade behind the British ascendancy to steam. MacGregor (1984:17) has graphed the built tonnage of sail versus steam in Great Britain from 1815-1905. From 1868-1877 production of sail and steam tonnage was relatively even; however, after 1877 the production of merchant steam vessels clearly dominated. In the United States, steam tonnage production did not pull ahead of sail tonnage for all time until 1885. Five years later, in 1890, the number of casualties occurring to steam vessels on the Pacific coast first caught up with the number for sailing vessels (Figure IV-6). The number of casualties for steam versus sail stayed relatively even until 1903 when casualties to steamers soared by comparison with sailing vessels which fell off dramatically (U.S. Treasury Department 1876-1914).

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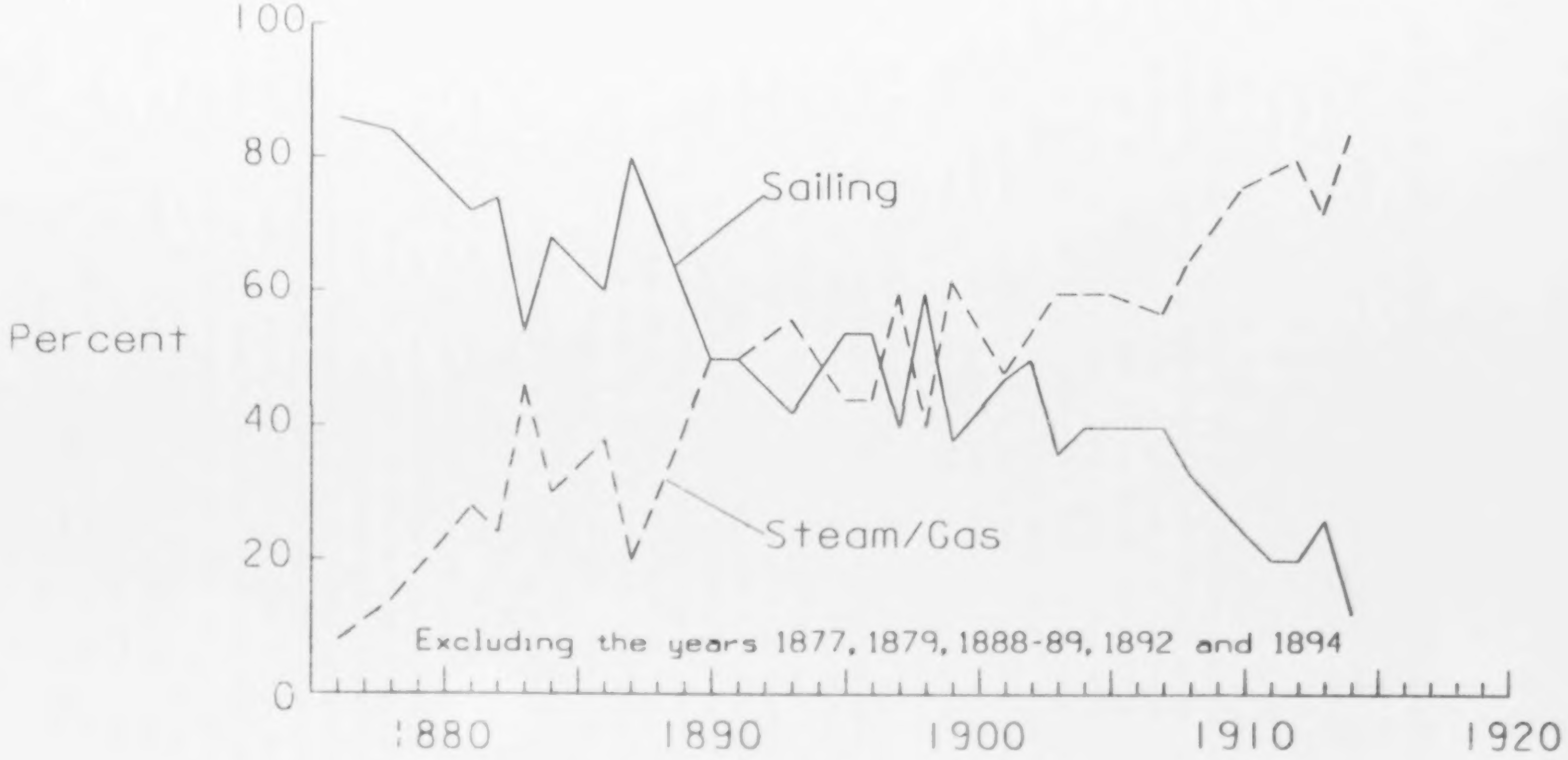
[1] Propellers had generally been adopted as the mode of propulsion for American coasting steamers built after 1842. By 1850 the screw superseded the paddlewheel for deepsea coasting steamers. In 1868, 36 percent of American steamers were built with screw propulsion. The next year this increased to 48 percent and, by 1873, had risen to 62 percent. From 1873 through the end of the century, 50-60 percent of all new steamers had propellors (Fairburn 1945:1376; 1401).

The peak of sail tonnage produced in the U.S. occurred in 1855. In that year 1,781 merchant sailing vessels were built, including: 381 ships and barks; 126 brigs; 605 schooners and 669 sloops. Steam tonnage, however, rose steadily throughout the nineteenth century, picking up momentum in the 1850s. Over the course of the century, ocean-going steam vessels evolved from sailing ships having auxiliary steam power to steam vessels having auxiliary sail power. "...until almost the end of the nineteenth century, every steamship was...fully rigged for sail, for no one knew when the engines might break down, or if a storm would delay the ship until its coal supply became exhausted" (Tate 1986:21). Ironically, during the latter half of the century, steam-powered tugs regularly sold their services to tow sailing ships in and out of harbors. The irony increased in the 1880s as many of these same sailing ships were taken out of service, cut down to become "schooner barges", and towed behind steam tugs in the coastwise trade, thus helping to hasten their own demise.

Prior to the 1880s, most tow barges were small scows, built for use in protected waters. As the number of steamers grew, a demand also grew for ship-shaped barges that were suitable for long open-sea hauls. In order to reduce the number of barges towed behind a single tug, longer barges were also coming into demand. Although shipyards built many such barges from scratch, a great number of old square-riggers and schooners ended their days in the tow of a steam tug. The drastic increase in the size of coasting schooners during the 30 years from 1880-1910 was a direct reaction to the rise in coastwise barge traffic. The high cargo capacity of barge strings, essentially floating trains, brought about rapidly falling freight rates. By 1910, the profit margin for schooners had been cut to the breaking point by barge competition for freight. After 1910 there was little incentive for owners to build and maintain schooners for coastwise trade. In 1938, the last American five-masted schooner remaining in commission, the *Edna Hoyt* (built in 1921), was retired as a coal barge (Fairburn 1945:2622-2626).

By 1910 steam was the undisputed champion of deepsea trade, as was the steam tug-towing barge combination in coastwise trade. The steam-powered screw remained the dominant source of propulsion up until 1941. Steel was becoming the material of choice for large ocean-going vessels. Passenger liners, warships, freighters and tankers were built exclusively of steel. The history of steamers in the transpacific trade has been summarized well in E. Mowbray Tate's illustrated book *Transpacific Steam* (1986). The outbreak of World War II signalled the end of the great steamers in the Pacific trade. To a large extent, their role was taken over by the Liberty ships mass produced during World War II (Lane et al. 1951).

The revolution of the internal combustion engine undoubtedly had a profound effect on small watercraft, such as fishing boats, as the twentieth century progressed and these engines became less expensive. Some nineteenth-century trawlers were apparently supplied with steam engines; however, the majority of the larger fishing vessels were schooners and sloops. In 1880, the Pacific coast fishing fleet totalled 5,603 craft, including 5,547 "boats" of various sizes and 56 "vessels." Fishing vessels, primarily schooners, averaged 98 tons in 1880 and had an average value of $9,758. In that year, Pacific coast fishing employed 11,613 persons at sea (Fairburn 1945:1059). Fairburn does not give statistics regarding the twentieth-century fishing fleet, although a sharper model of schooner apparently came into wide use.



Based on statistics from U.S. Treasury Department, 1876-1914.

Figure IV-6. Average Annual Frequencies (%) of Casualties Involving Sailing Versus Steam/Gas Vessels, 1876-1914.

2.4.2 *Shipwreck Statistics*

The shipwreck database compiled as part of this study contains an estimated 4,676 unique wreck listings for the Pacific coast of the United States. Of this number, 826 listings pertain to wrecks in southern California that had been entered into the database as part of an earlier MMS-sponsored study covering that region (Pierson et al. 1987). The database contains records for an estimated 3,850 unique wreck events from within the study area. The database admittedly contains a subset of the total shipwreck population; however, this number is believed to represent a significant proportion of historic vessels wrecked in the study region. An important exception is the large number of small watercraft, both indigenous and historic, including most fishing vessels, which were never registered with a governmental body thus were never recorded in history.

Information has been summarized from the database in a number of ways for discussion in this report, including: the distribution of shipwrecks through time; the geographic distribution of wrecks along the coast by county; and the relative proportions of different vessel types wrecked along the Pacific coast. Statistical information derived from the database has been summarized for the entire west coast, thus percentages computed are based on totals for the entire database as opposed to that portion pertaining only to the study area.

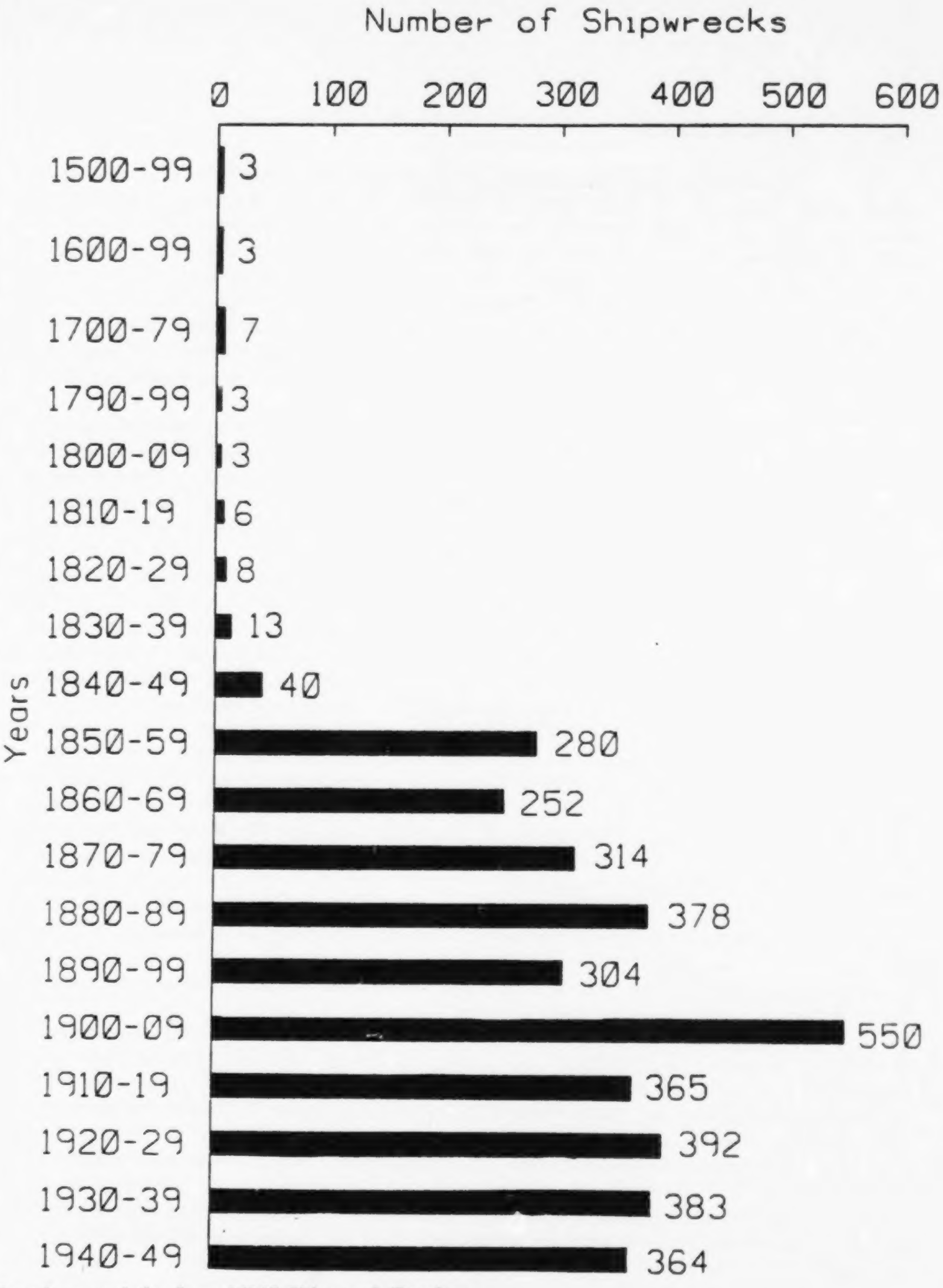
Figure IV-7 illustrates the temporal distribution of shipwrecks occurring along the west coast. Each bar represents the total number of shipwrecks contained in the database for the decade in question. It should be noted here that the total volume of shipwrecks for the 1940s may be somewhat larger than indicated by Figure IV-7, as the cut-off date for this study is 1946. From the earliest wreck in 1540 (in southern California) up to the 1790s there were numerous decades in which no record of shipwrecks was found (the early timeline has been compressed in Figure IV-7 to exclude these periods). The small number of shipwrecks recorded prior to the nineteenth century is a reflection of the sparse maritime traffic along the west coast at that time.

The first significant increase in the number of wrecks was during the 1840s when the number tripled from the previous decade, although still a relatively low number by comparison with what followed the gold rush. The number of shipwrecks increased by 700 percent during the decade of the 1850s. Various ups and downs in decade totals occurred throughout the one-hundred-year period following the gold rush.

If maritime activity were dependent solely upon population growth, one might expect a steady increase in the number of wrecks over the decades. The fluctuations illustrated in Figure IV-7 are probably most closely linked to swings in the maritime economy. For example, the drop in number of wrecks during the 1860s may be largely due to a slump in U.S. maritime trade during the Civil War. A similar deline in trade occurred during World War I.

The figures prior to the mid-1870s may be biased toward a lower-than-actual number of wrecks. Beginning in the 1870s, the quantity of official records associated with vessel registration, inspection, and customs clearances is much greater than for any prior period. The United States Life-Saving and United States Lighthouse services were also established during the 1870s, resulting in an increase in the proportion of wrecks reported.

It is difficult to estimate the effect that technological improvements such as improved navigational aids, iron and steel hulls, and steam and gas engines had on the number of wrecks. To do so would entail compensating both for fluctuations in the total volume of shipping in the area due to economic trends and for the general growth of the Pacific coast maritime economy. One might suspect the effects of technology, however, to be more subtle than those of economy, since the transition to and perfection of these technologies was a gradual process.



Based on statistics from MMS Shipwreck Database.

Figure IV-7. Temporal Distribution of Shipwrecks Along the Pacific Coast, by decade.

Table IV-1 contains a shipwreck summary organized by county. Locational information at the county level or better has been entered for an estimated 3,516 unique wreck events. County names in Table IV-1 are listed geographically with the northernmost placed at the top of the table and the southernmost at the bottom. The greatest numbers of wrecks occurred, as expected, in counties having major harbors. This distribution is even more pronounced when comparing the number of wrecks per linear mile of Pacific coastline for each county. The distribution of shipwrecks laterally along the coast is discussed in more detail in Section 5.5 of this volume.

The spread of maritime trade along the west coast through time is reflected by the dates in the last column of Table IV-1 for each county. The earliest of each pair of dates is the year of the earliest shipwreck listed in the database for each county. The later date of each pair is the year in which each county experienced its tenth shipwreck. Looking back to Figure IV-7, notice the radical increase in the number of shipwrecks beginning in the 1850s. This increase is due to the explosion of trade during and following the gold rush. Counties in which ten ships had wrecked by the early part of the 1850s were obviously involved to some extent in the economic boom that began with the gold rush.

Table IV-1 indicates that many counties did not experience their first shipwreck until the 1850s. While earlier unrecorded wrecks have undoubtedly occurred in some of these counties, it would be safe to assume that these counties had very few wrecks prior to that time. San Francisco and the counties adjoining San Francisco Bay (except Marin) are good examples. The Point Reyes peninsula in Marin County attracted a small number of earlier wrecks including the *San Agustin* in 1595, the earliest known wreck in the study area. Counties lacking major harbors, for example Jefferson County in Washington and Del Norte County in California, were slower to develop economically and were bypassed by most maritime traffic. As a result, a much greater period of time passed before ten wrecks had occurred in these counties. In general, the dates in Table IV-1 seem to reflect the progression of economic development along the Pacific coast.

A variety of vessel types have wrecked along the Pacific coast. In general the relative frequency of vessels lost for each type should reflect the relative abundance of that type active in maritime commerce in the study area and along the Pacific coast. There are, however, at least two important exceptions to this supposition. First of all, iron- and steel-hulled vessels, primarily oceanic steamers, may have experienced proportionally fewer wrecks resulting in total loss of the vessels than may have been the case with wooden-hulled vessels. This expectation is due to the presumed greater hull strength of iron and steel over wood and to the greater reliability of steam power in unfavorable winds. Secondly, vessels involved primarily in coastwise trade, most notably schooners, are likely to experience a greater number of losses, proportional to the number of vessels sailing, than vessels involved in the transpacific trade. This is due to the generally greater hazards associated with sailing along the coast and into dog-hole harbors than with sailing in the open sea.

The United States Life-Saving Service began publishing statistics on marine casualties and losses, gathered from the U.S. Customs Service, in 1876 and continued this practice through 1914. The statistics summarized in Figure IV-8 represent the relative frequencies of casualties experienced by vessels of different types from 1876-1914 along the Pacific coast. The types of casualties involved and their distinction from shipwrecks are important topics that are described in detail in Section 5.1 of this volume. For now it is merely emphasized that the percentages of total casualties represented for different vessel types in Figure IV-8 is not an accurate reflection of the proportion of vessel types lost.

Figure IV-8 attributes 54.8 percent of all casualties to steamers as opposed to only 28.3 percent for schooners. This was the height of the coastwise schooner trade, however, and schooners greatly outnumbered steamers throughout the period. The relatively higher proportion

TABLE IV-1

SUMMARY OF SHIPWRECK STATISTICS, INCLUDING FREQUENCY OF WRECKS PER LINEAR MILE, FOR PACIFIC COAST COUNTIES

County	Total Wrecks	Percent of Total	Wrecks Per Mile	Time Span of First Ten Wrecks
Clallam	93	2.7	2.5	1808-1864
Jefferson	25	0.7	0.9	1775-1906
Grays Harbor	78	2.2	1.5	1837-1892
Pacific	102	2.9	2.6	1822-1869
Clatsop	324	9.3	9.6	1725-1839
Tillamook	68	1.9	1.3	1679-1887
Lincoln	79	2.3	1.5	1809-1865
Lane	50	1.4	1.8	1856-1892
Douglas	69	2.0	3.9	1808-1860
Coos	300	8.6	6.3	1852-1856
Curry	101	2.9	1.5	1830-1856
Del Norte	49	1.4	1.2	1850-1877
Humboldt	203	5.8	1.8	1850-1853
Mendocino	254	7.3	2.7	1852-1855
Sonoma	140	4.0	3.2	1854-1871
Marin	281	8.0	6.5	1595-1853
Contra Costa	24	0.7		
Alameda	17	0.5		
Santa Clara	0	0.0		
San Francisco	246	7.0		1850-1854
Subtotal for San Francisco Bay	**287**	**8.2**	**40.4***	
San Mateo	99	2.8	2.1	1850-1863
Santa Cruz	22	0.6	0.2	1852-1919
Monterey	81	2.3	3.3	1831-1875
San Luis Obispo	21	0.6	0.3	1852-1916
Santa Barbara	180	5.1	1.8	1801-1857
Ventura	70	2.0	1.8	1824-1881
Los Angeles	378	10.8	5.9	1598-1855
Orange	42	1.2	1.1	1854-1934
San Diego	120	3.4	1.7	1540-1873
TOTAL	3,516			

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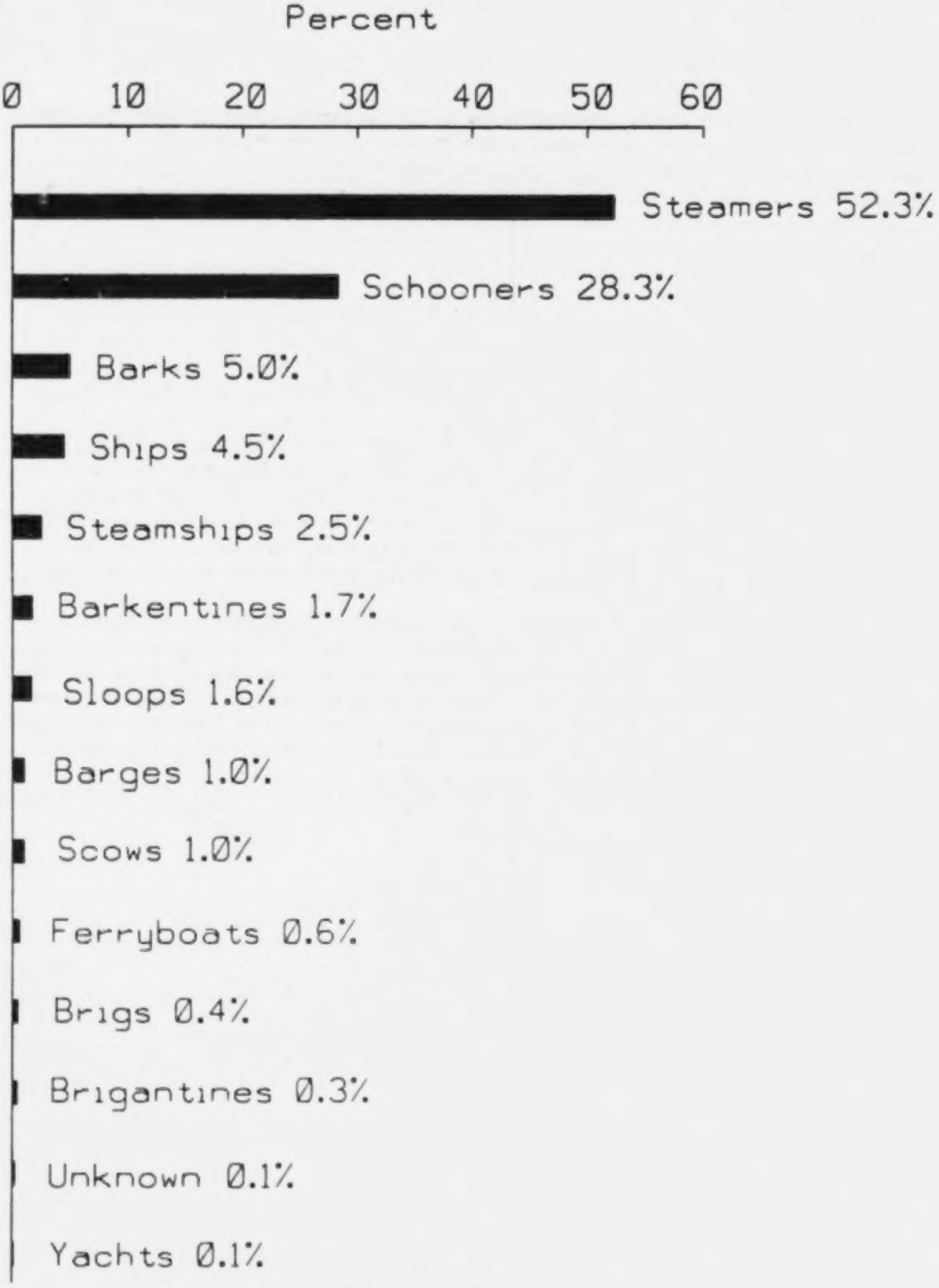
* Based on mileage for Pacific coastline of San Francisco County and total wrecks for San Francisco Bay area.

Source: Statistics from MMS Shipwreck Database.



Based on statistics from U.S. Treasury Department, 1876-1914.

Figure IV-8. Frequency (%) of Casualties by Vessel Type, 1876-1914.

of casualties to steamers may be explained by the fact that steamers were more highly regulated than schooners, thus a greater proportion of relatively minor casualties, broken spars for example, were likely to have been reported for steamers than for schooners. Part of the difference between steamers and schooners may also have been due to the relative inexperience of steamers in the Pacific coastwise and transpacific trade, whereas schooners had been in common use since the California gold rush.

By comparison with Figure IV-8, Figure IV-9 illustrates the proportion of shipwrecks from the MMS database which occurred to each major vessel type for the entire historic period. Only the most commonly occurring vessel types are included in Figure IV-9. A complete list of vessel types represented in the database for the Pacific coast can be found in Appendix G. Appendix G also indicates the number of unique wreck events within each category.

The most noticeable feature of Figure IV-9 is the dominance of schooners over all other vessel types. Approximately 30 percent of all shipwrecks having occurred along the Pacific coast were schooners as opposed to 20 percent for steamers. These figures appear much closer to the relative frequency of each type in the American merchant fleet throughout the nineteenth and twentieth centuries (see Fairburn 1945 and Section 2.4.1 above). The high frequency of schooners wrecked along the Pacific coast is reflective of the high proportion of ships wrecked by stranding (discussed in sections 5.2 and 5.5; also see Table IV-4). Schooners, having been the most commonly used vessel in coastwise trade, should also have been the type most frequently stranded.

Another notable feature of Figure IV-9 is the importance of gasoline- and oil-powered (diesel) vessels relative to the frequency of other vessels wrecked. The vast majority of gas- and oil-powered vessels wrecked during the twentieth century. As a combined class of vessels, gas- and oil-powered account for 15.4 percent of all shipwrecks along the Pacific coast. By comparison, merchant sailing vessels account for 44.2 percent; steamers account for 19.7 percent; and barges and scows total a combined 5.0 percent. The remaining 15.7 percent of shipwrecks in the database consist of various "other" types of vessels (see Appendix G).

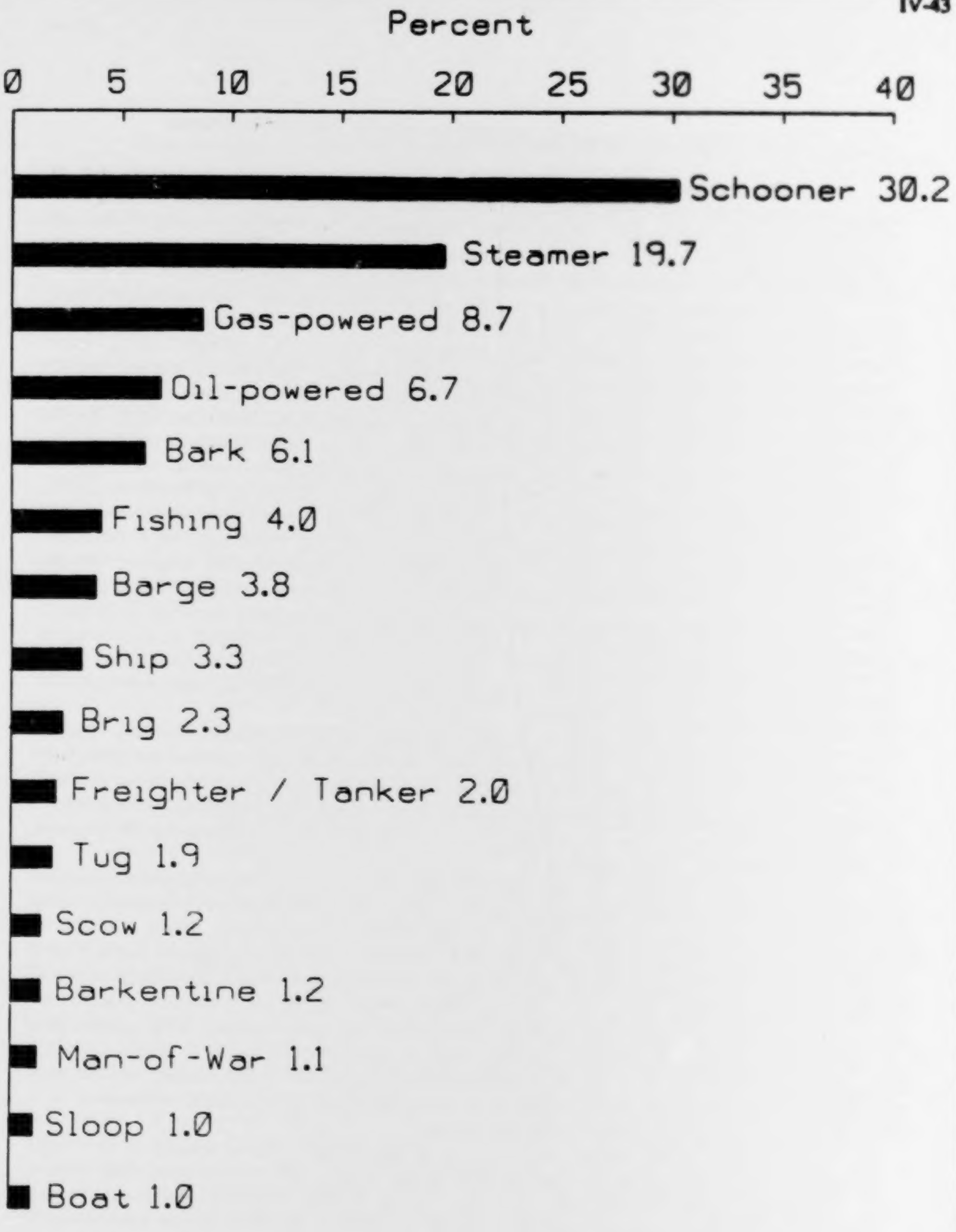


Figure IV-9. Relative Frequencies (%) of Shipwrecks by Vessel Type.

3.0 PREVIOUS MARINE ARCHAEOLOGICAL INVESTIGATIONS

The archaeology of maritime topics has held a fascination for generations of enthusiasts along the Pacific coast. Even before the age of sail had ended, scholars contemplated the period of earliest exploration. Much of their fascination lay with finding physical evidence to corroborate historic accounts of exploration. Then, as now, the discovery of artifacts or the bones of a ship washed onto the beach could stimulate speculation about what lay beneath the waves.

During the nineteenth century, one such wreck that aroused much scholarly debate was the Nehalem Beeswax Wreck. Quantities of beeswax, a common cargo on Manila galleons, had been recovered from the beach by Native Americans. According to Wright (1895), Native American oral tradition dated this wreck to the eighteenth century. The location, age and identity of the Beeswax Wreck have been a source of debate. Wright believed the wreck to be that of a galleon lost in 1772. Originally reported as being at the mouth of the Columbia River, Wright correctly identified the source of the beeswax as the mouth of the Nehalem River. Although the precise location of the Beeswax Wreck has never been located, subsequent research has suggested that the wreck may be that of the *San Francisco Xavier*, lost in 1707 (Cook 1973; Schurz 1939). A specimen of beeswax in the collection of the Tillamook County Pioneer Museum, presumeably from this wreck, has been Carbon-14 dated between 450 and 300 B.P. (1989 letter from Tillamook County Pioneer Museum to EH&A). J. Nielson Barry, an Oregon historian, suggests that the Spanish survivors of this wreck had traded oriental coins to the Indians (Barry 1932:36 cited in Beals 1980:61). Interesting enough, at least 18 Chinese coins, dating from the reign of Emperor Kang Hsi (1662-1722), have been found by archaeologists at four aboriginal sites in Oregon between 1934 and 1973 (Beals 1980:68-70). These Kang Hsi coins may be among the oldest oriental coins to be found on the Pacific coast, even though the Chinese have used metallic coins for well over 2,000 years (Beals 1980:58).

Another topic of interest to nineteenth-century as well as twentieth-century scholars has been that of pre-Columbian transpacific voyages. Early ethnographers had noticed a similarity between certain physical characteristics of North American Indians and those of Asian populations. It was also known that Japanese vessels had drifted across the northern Pacific and washed ashore on the northwest coast. The latter observation seemed a good explanation for the physical resemblance between distant populations.

In 1872, Horace Davis read a paper before the American Antiquarian Society entitled "Records of Japanese Vessels Driven upon the Northwest Coast of North America and its Outlying Islands." Three years later, Charles Wolcott Brooks (1875), perhaps borrowing from the ideas of Davis, read a similar paper, "Japanese Wrecks Stranded and Picked up Adrift in the North Pacific Ocean," before the California Academy of Sciences. Brooks contended that this pattern of vessel drift was evidence for an infusion of Japanese blood among the Indian tribes of the northwest coast. Speculation regarding pre-Columbian transpacific contact has continued to the present with archaeological evidence forming the primary basis for argument (for example: Ekholm (1953); Meggers et al. (1965); Riley et al. (1971); Mertz (1972); Kehoe (1978; 1990); Pierson and Moriarty (1980); Needham and Lu (1985)). Despite mounting evidence, the academic community, as a whole, remains hesitant to embrace this idea as fact.

In 1895, E.W. Wright completed *Lewis and Dryden's Marine History of the Pacific Northwest*. This work summarized the maritime history of much of the study area while history, from the perspective of this study, was still in the making. Wright wrote this volume with a heavy emphasis on particulars, especially names of seamen and vessels. Although not an archaeological study, Wright did synopsize vessel losses year by year, making this work invaluable from an archaeological perspective.

Two particular voyages to the coast of California, Sir Francis Drake's visit in 1579 and Sebastian Rodriguez Cermeno's loss of the *San Agustin* there in 1595, have been the impetus behind much of the maritime archaeology that was done on the west coast prior to the 1960s. Both Drake and Cermeno are believed to have landed in Drakes Bay on the Point Reyes Peninsula. Drake stopped over for repairs to the *Golden Hind*. Cermeno stopped to claim land for Spain and lost his ship during a storm while he was on shore. The *San Agustin* is the oldest historically documented shipwreck in the study area.

During the early twentieth century, interest in Drake's and Cermeno's voyages was peaked by archaeological finds of Chinese porcelain in coastal shell midden sites on Point Reyes Peninsula and along the beaches of Drakes Bay. There have been numerous archaeological surveys and excavations of coastal Indian sites conducted since that time (Kelly 1982). A major emphasis of this work has been to substantiate historical accounts of these early voyages and to pinpoint as closely as possible the points where these two explorers landed (Nuttall 1914; Wagner 1924, 1926).

Beginning about 1940, archaeological investigations occurred with increasing frequency. Robert Heizer (1942) published an article citing archaeological evidence for the wreck of Cermeno's vessel *San Agustin*. Since then, a number of articles have been published on the archaeology of the Drake and Cermeno expeditions, including Meighan (1950), Meighan and Heizer (1952), Treganza (1957), Aker (1965), Huston (1965), Treganza and King (1968), and Von Der Porten (1973).

Archaeological investigations after about 1940 began to approach the problem from a more scientific perspective. For example, Fink and Polushkin (1942) conducted a metallurgical analysis of several iron spikes found on historic Native American sites in the vicinity and concluded that they were of sufficient antiquity to have come from the *San Agustin*. Chinese porcelains from 12 coastal Miwok sites have more recently been analyzed to determine their age. Shangrew and Von Der Porten (1981 cited by Kelly 1982) looked at 235 porcelain fragments dating from the Ming Dynasty and concluded that two-thirds were too recent to have originated from Drake's visit but were of the proper age to be associated with Cermeno's voyage 16 years later. The other third of the porcelain fragments may have been left with the Miwok by Drake's expedition. In 1981, five iron cannons were recovered near Galeta in Santa Barbara County, California. While it has been suggested that these were brought ashore by Sir Francis Drake in 1579, a recent analysis of the cannons suggests that they are more likely of eighteenth-century origin (Snethkamp et al. 1990).

One of the first marine applications of a magnetometer was a survey at Drakes Bay in 1965 by John Huston (Huston 1965), founder of the Advisory Council on Underwater Archaeology. One of the goals of Huston's survey was the discovery of the *San Agustin*. In 1982, the NPS conducted a much more extensive survey of the bay in hopes of identifying historic wreck sites, including that of the *San Agustin* (Murphy et al. 1984). A number of anomalies have been located in Drakes Bay as a result of both surveys; however, the *San Agustin* has not been positively identified. The search for the *San Agustin* by private interests has continued to the present.

Interest in marine archaeology began to accelerate in the 1970s (e.g., Hudson 1976). The passage of environmental legislation in the late 1960s and early 1970s and the concept of cultural resource management (CRM) began to play a major role in maritime archaeological investigations by the mid-1970s. Federal agencies, such as the National Park Service (NPS), the U.S. Army Corps of Engineers (USCE), and the Minerals Management Service (MMS), were faced with the responsibility of managing archaeological and historical sites on submerged lands within their jurisdiction. Since the 1970s, other government agencies have also begun to sponsor marine archaeological studies in compliance with Section 106 requirements of the National Historic Preservation Act.

The NPS has played a major role in the inventory and assessment of submerged cultural resources due to the large amount of NPS lands bordering the Pacific coast. Two areas have received extensive attention: Channel Islands Park in southern California (Glassow 1977; Howorth and Hudson 1985; Haller and Kelly 1988; and Morris 1990) and Point Reyes National Seashore/Point Reyes-Farallon Islands National Marine Sanctuary (Moratto 1974; Murphy et al. 1984; and Delgado and Haller 1989). Emphasis in both areas was largely directed toward identifying submerged and stranded shipwreck sites that are potentially eligible for the National Register of Historic Places. The historic background of 151 shipwrecks present in Federal waters and beaches near San Francisco has recently been published jointly by the NPS and NOAA (Delgado and Haller 1989). A number of NPS investigations also have been conducted as a result of severe winter storm erosion along the California coast in 1982 and 1983. In particular, storm erosion led to the discovery of the two-masted schooner *Neptune* (Delgado 1986b) and the three-masted ship *King Philip* at San Francisco (Delgado 1983, 1986a; Kelly 1983), the steam schooner *Point Arena*, the steamer *City of Columbia*, and the bark *J.W. Seaver* at Año Nuevo State Reserve south of San Francisco, and remains of the 1903 steam schooner *Pano* on the Point Reyes peninsula (Delgado 1984).

The USCE has likewise sponsored a number of CRM studies of submerged lands in connection with harbor and channel improvements. During the 1970s, this work was conducted almost exclusively through the Los Angeles District of the USCE (Environmental Research Archaeologists 1977; Weinman 1978; Hunter 1979). By 1985 the Portland District of the USCE had begun a systematic compilation of historic data regarding shipwrecks and was conducting remote-sensing surveys of dredge disposal sites on a regular basis in search of potential shipwrecks within specific project areas (USCE 1985, 1987a, 1987b, 1988a, 1988b, 1989). More recently, the Seattle District of the USCE has been contracting for in-depth historic and archaeological remote-sensing studies in Puget Sound (Evans Hamilton, Inc. 1988a, 1988b).

Very few marine archaeological investigations have been sponsored by any source other than the USCE, in Washington and Oregon, and to date, only one shipwreck, the *Isabella*, has been listed on the National Register of Historic Places for the state of Oregon. The *Isabella* was a two-masted British supply ship for the Hudson's Bay Company. Built in 1825, she wrecked in 1830 on Land Island near the mouth of the Columbia River with a cargo of supplies for the fur trade. Archaeological excavations were conducted on the site by the NPS during the mid-1980s (Thomson 1988). During the early 1980s, a fledgling program in underwater archaeology, the Center for Marine Archaeology, was begun at Central Washington University under the direction of Dr. William Smith. The primary objective of this program was to develop predictive models for both prehistoric and historic site distributions on the continental shelf of Washington State. Beginning with the San Juan Islands in Puget Sound, a preliminary model for prehistoric sites was developed (Grebmeirer 1983). Unfortunately, the Center for Marine Archaeology lost its funding and was forced to close only 14 months after its inception. No fieldwork was ever conducted (William Smith; personal communication to R.L. Gearhart, November 27, 1990).

The first MMS baseline study along the Pacific coast was completed for southern California in 1977 (Stickel et al. 1977) due to ongoing mineral development on the OCS at that time. A second study of this area was conducted for MMS by Pierson et al. (1987). A number of remote sensing surveys had been completed on the OCS off of southern California by the time of this second study. There has been no mineral development or exploratory drilling in the study area, and the present study is the first MMS-sponsored archaeological investigation of this area.

Beginning in the 1980s, rapid development of Los Angeles Harbor resulted in a corresponding increase in the number of archaeological projects conducted in the area. Responsibility for these projects began to fall on the port authorities of Los Angeles and Long Beach, although the work was generally conducted to meet USCE permit requirements. Investigations conducted in connection with the development of Los Angeles Harbor include: Port of Los Angeles (1980); Pierson (1980a); Hunter and Pierson (1980); Stickel (1982, 1984 and 1985); Tetra Tech (1984); Pettus (1985); and Schwartz (1989).

An increasing amount of maritime archaeology has been conducted, since the late 1970s, as a result of urban development. The city of San Francisco has sponsored a number of sizeable archaeological investigations on maritime sites, although not all of these have been submerged. For example, in the late 1970s the store ship *Niantic* was uncovered along the historic San Francisco waterfront (Delgado 1979; Smith 1981). The *Niantic* was a three-masted, 120-ft ship (b. 1835) used as a store ship along the San Francisco waterfront during the gold rush. The *Niantic* arrived in San Francisco in 1849, burned in 1851 and was subsequently buried. In 1978 the remains of the *Niantic's* hull were unearthed during construction of an office building. The artifacts discovered in the *Niantic* are an invaluable collection of merchandise from the height of the California gold rush. Shortly after the discovery of the *Niantic*, another vessel, the *Lydia* (also known as the King Street ship) was discovered, buried along the historic San Francisco waterfront. The *Lydia* was a three-masted, 106-ft whaling bark, built in 1840. In 1978 the remains of this vessel were unearthed near the foot of King Street while excavating to construct a larger sewer tunnel. Emergency salvage archaeology was conducted, and a portion of the vessel's midship section was removed. The San Francisco Clean Water Program sponsored a four-volume study of the San Francisco waterfront (Pastron et al. 1981) that included a detailed analysis of the *Lydia* (Olmsted et al. 1981). The remains of a third vessel, believed to be the 1827 packet ship *William Gray*, were unearthed in 1979 near the intersection of Battery and Tilbert streets in San Francisco. The *William Gray* was a 296-ton, 109-ft ship whose hull was used as a buttress for a gold rush wharf in 1852. This site remains buried beneath a park in Levi's Plaza (Pastron and Prichett 1979 cited in Pastron and Hattori 1990).

Erosional problems along San Francisco's Ocean Beach have resulted in a number of archaeological studies being conducted in this area. In the late 1970s, the city was planning construction of a large wastewater tunnel adjacent the beach. During the planning stage, Olmsted and Olmsted (1979) conducted an historic analysis of erosion along Ocean Beach. One result of their study was the conclusion by NPS staff that archaeological shipwreck sites might occur beneath the modern dune front due to shifts in the shoreline and dunes. The potential for disturbance of historically documented wreck sites along Ocean Beach was highlighted in 1983 and 1984 when severe winter erosion exposed the remains of the medium clipper ship *King Philip* on the beach (Figure IV-10).

Since 1983 a number of archaeological studies have been conducted on Ocean Beach, the latest related to seawall construction. In 1987 and 1988, Espey, Huston & Associates, Inc. conducted a terrestrial magnetometer survey of a 2,770-ft section of Ocean Beach, encompassing as many as four historic wreck sites (Gearhart 1988). The remains of two shipwrecks, the medium clipper *King Philip* (1856-1878) and the lumber schooner *Reporter* (1876-1902), were verified by the magnetometer survey (Figure IV-11). Two other probable shipwreck sites were also located by the survey, believed to be the remains of a New Bedford whaling bark, *Atlantic* (1851-1886), and the steam schooner *Aberdeen* (1899-1916) (Kelly 1983; Delgado et al. 1984; Gearhart 1988).

Inland from San Francisco, the city of Sacramento has sponsored a number of marine archaeological studies along the historic Sacramento River waterfront. This work has been done

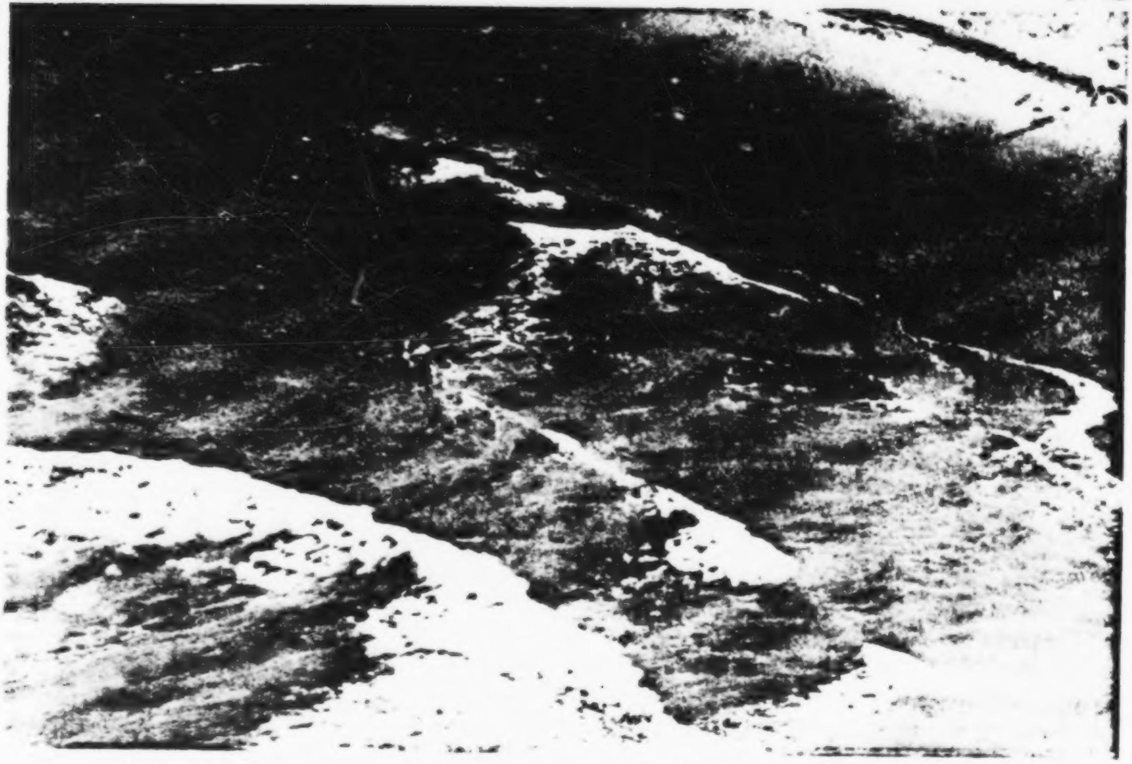


Figure IV-10. *King Philip* Hull at Maximum Exposure During Spring of 1983 (photo courtesy of National Park Service, San Francisco, California).

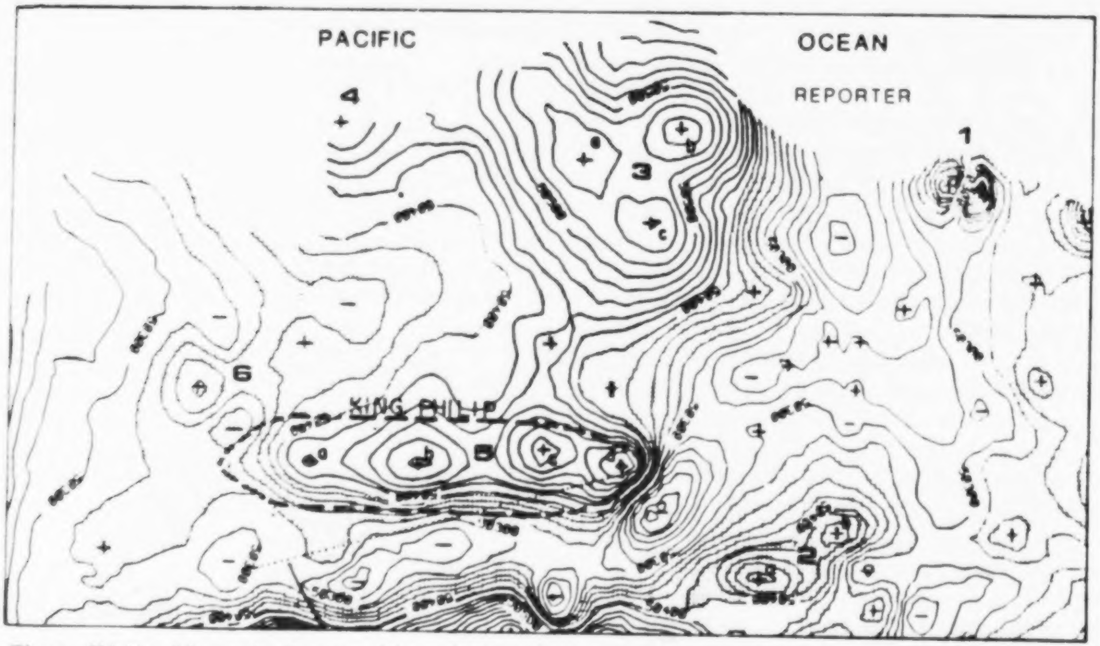

PACIFIC
OCEAN
REPORTER
4
1
3
6
KING PHILIP
5
2

Figure IV-11. Magnetic Contour Map of *King Philip* and *Reporter* Wreck Sites on Ocean Beach in San Francisco (Gearhart, 1988).

for the Sacramento Housing and Redevelopment Agency under the review of the California Department of Parks and Recreation. A number of historic shipwrecks have been discovered along the waterfront including: the probable remains of the brig *Sterling* (Hunter et al. 1984; James 1984); the remains of a vessel believed to be either that of the prison ship *La Grange* (James 1986a) or that of the *Mazeppa* or a "Cooper's ship"; and the remains of an ocean-going sailing vessel believed to be either the brig *Dimon* or the bark *Ninus* (James 1986b).

4.0 LITERATURE SEARCH AND DATA ACQUISITION

A vast body of literature exists concerning the maritime history and archaeology of the study region. The first goal of this subtask was to compile a thorough bibliography of pertinent sources, both published and unpublished. Published references were identified from existing bibliographies and from extensive searches of library card catalogs. Some unpublished material was also discovered in this manner, as well as from various archival finding aides. A bibliography resulting from the literature search for published sources and unpublished manuscript material is included as Appendix B. A bibliography of references pertinent to documenting vessel losses was compiled as part of the shipwreck database and is reproduced as Appendix G.

4.1 Results of Museum and Library Survey

The majority of unpublished information utilized for this study was identified through conversations with numerous knowledgeable individuals. A partial list of individuals contacted in connection with maritime aspects of this project is provided in Appendix D in Volume VI. Other unpublished sources were identified by means of two questionnaires sent out through the mail.

The first questionnaire was mailed to historical societies, maritime museums, and institutions along the west coast. The level of response was very favorable. The format of this questionnaire and the results are included as Appendix D. The second questionnaire was designed specifically to locate collections of historic newspapers and to determine which of these collections have been indexed. The results of this mailout have been summarized as Appendix F of Volume VI.

4.2 Sources of Shipwreck Data

Compilation of the shipwreck database relied on a large number of sources, both published and unpublished. A substantial amount of research had been done toward this end independently of and prior to this study by several private individuals and by persons associated with various governmental agencies. As a result, several computerized databases existed, although in different formats, which were combined into one database by EH&A as the initial step toward populating the MMS wreck database. These databases include, in the order that they were obtained: 1) the MMS database for the Southern California Planning Area, assembled by Pierson et al. (1987), with additions by Alex Watt of MMS' Pacific OCS office in Los Angeles; this database contained numerous wrecks which are located in the current study area; 2) a database assembled by Steven Schwartz, then of the Los Angeles District USCE, now employed by the U.S. Navy at Point Mugu, California; 3) a database from the Oregon State Historic Preservation Office, provided by Leland Gilsen; 4) the database of the National Maritime Initiative (those portions pertaining to the study region), provided by Candace Clifford; and 5) a database from the Portland District USCE, provided by Michael Martin and Ann Dienes. A sixth database was hand-entered into a computer by EH&A from an extensive listing of wrecks contained on a map compiled by Lt. Comdr. W.A. Mason, U.S.N. (1935).

Once these six databases were merged into the MMS format and were edited to eliminate duplicates, misspellings and erroneous dates, the task of searching published and non-published sources for new listings began. A complete listing of sources utilized in populating the shipwreck database is provided in Appendix G. After the database compilation was well underway, two additional computerized databases were encountered. One of these was compiled by Heather MacFarlane and the other by the California State Lands Commission. Due to our relatively late

acquisition of the MacFarlane database, it has not been merged with the MMS database. The sources used in its compilation, however, were researched by the compilers of the various other databases utilized, and/or by EH&A. The State Lands Commission provided a list of the sources used in the compilation of their database. The major sources used to compile the State Lands Commission database also occur on the source list for MMS' database; thus, no attempt was made to merge the former with the study database.

Once the various shipwreck databases were merged the slow task of comparing the resulting composite database with primary and secondary sources began. The number of sources containing information on vessel losses is overwhelming. More such sources were available than could have been completely searched in the time allowed for this project. As a result, sources were selected based upon the relative number of new wreck listings they would likely contain. Several sources were abandoned after an initial search turned up practically no new information. The following subsections discuss the major sources available, in addition to the computerized databases mentioned above, and specifies which were relied upon most heavily in the compilation of the shipwreck database for this study. Numerous sources of information were utilized that are not described below, while some of the material discussed here actually played a small part in the database compilation but are, nevertheless, valuable sources. A listing of the sources used in compiling the MMS shipwreck database and the Historic Site Location Maps is provided at the end of this volume as Appendix E.

4.2.1 Primary Sources

Primary sources are by far the most reliable and informative for data pertaining to shipwrecks and other marine disasters. They are also the most difficult for researchers to use. They exist in multiple repositories across the country; they cannot be checked out, requiring the researcher to travel and limiting research to business hours; and they are almost never indexed, meaning that the researcher must pour through endless pages and volumes of non-pertinent information for a seemingly minute return of useful information.

Fortunately, several of the primary sources useful to this project have been condensed into annual government publications. Unfortunately, these publications do not generally contain a comprehensive list of the wreck events described in the corresponding primary source for any given year. Just as many primary sources have not been condensed as have been.

Compiling a truly comprehensive list of wrecks for the study region would require a thorough perusal of every existing primary source, a gargantuan task well beyond the scope of this project. Realizing the shortcomings of secondary source material, however, the authors have made every effort to examine those primary sources which provide the greatest return of information for the effort. Primary sources identified and located during the course of EH&A's research are described in detail below. The availability and usefulness of each is discussed along with the degree to which each was utilized in compiling the wreck database.

4.2.1.1 Life-Saving and Coast Guard Station Logbooks

The U.S. Life-Saving Service was created by Congress in 1871 in conjunction with the U.S. Revenue-Cutter Service for the purpose of rendering assistance to persons and vessels in distress. On 18 June 1878, Congress established the Life-Saving Service as a separate organization. The Pacific coast initially comprised the 11th District of the Life-Saving Service; however, this region was soon reassigned to the 12th District. The first Life-Saving Station on the Pacific coast was established at Shoalwater Bay, Washington, on 26 November 1877 (U.S. Treasury Department

1878). A second station was opened soon afterwards at Cape Disappointment, Washington, on 15 February 1878. By July of the same year, four additional stations were completed: Neah Bay, Washington; Cape Arago (Coos Bay), Oregon; Humboldt Bay, California; and Golden Gate Park in San Francisco. By 1914 at least 20 stations were operating on the Pacific coast, including 19 in the study area and one in Alaska.

The keeper of each life-saving station was required to keep a detailed log of assistance rendered to individuals and vessels in distress. These handwritten logbooks contain a great deal of information regarding wrecks in proximity to each life-saving station. Detailed descriptions of daily activities conducted by the crews of the stations can be found in these logs. This could include everything from rescuing a drowning person to delivering mail to preventing suicides to assisting vessels in distress. Since life-saving stations were constructed in high-traffic areas, a relatively large number of wrecks were reported. The entries are numerous. A large number of these logbooks have survived in their original handwritten form in the National Archives. The National Records Center (part of the National Archives) in Suitland, Maryland, has holdings of approximately 3,000 boxes of these logbooks (John Butler personal communication, 1990) for stations from around the country dating from 1873 to 1945 (beginning in 1915 the life-saving stations were transferred to the jurisdiction of the newly formed Coast Guard; however, the logbooks were still kept). Each box has about 3000 pages of handwritten entries, making a total of 9,000,000 pages (Jim Cassidy, 1990; personal communication). The records are arranged by Life-Saving District and then by station within each district.

It is beyond the scope of this project to read through these records. Fortunately, information pertaining to the major marine casualties was summarized in annual reports. At the end of each fiscal year, the activities of each station were summarized in tabular form in a government publication entitled, *Annual Report of the Operations of the United States Life-Saving Service* (U.S. Treasury Department 1876-1914). This series will be discussed in more detail under secondary sources; however, it must be pointed out that the *Annual Reports* list only those wrecks that were considered to be important (Sherman personal communication, 1990), for example, those involving extreme valor on the part of the life-saving crew or involving loss of life.

In 1915 the activities of the U.S. Life-Saving Service were transferred along with those of the U.S. Revenue-Cutter Service to the newly formed U.S. Coast Guard (USCG). The records of the Life-Saving Service were also transferred to the USCG. The life-saving stations continued to exist under the operation of the USCG and a record of assistance rendered continued to be submitted annually for use in publishing annual reports, called the *Annual Reports of the United States Coast Guard*. Under the USCG, the Pacific coast became the 13th District and the number of stations grew to 21, all of which were in the study region, except for Station No. 305 at Nome, Alaska. As the amount of vessel traffic increased, the amount of information contained in the *Annual Reports* decreased to the point that after 1921, they contain very few references to wrecks, except major marine catastrophies involving loss of life. Nevertheless, the logbooks continued to be kept at each life-saving station. These logbooks are an invaluable source for information pertaining to specific shipwrecks, provided the wreck occurred near one of the stations; however, it was not feasible to search this material when researching this project.

4.2.1.2 Light Station Logbooks

The keepers of lighthouses were also required to keep a daily record of events. Since lighthouses were strategically placed on headlands and islands, the keepers were often witness to shipwrecks. A number of logbooks from individual lighthouses for the period 1897 to 1946 are housed in the National Records Center in Suitland, Maryland (Butler personal communication, 1990). These records are apparently less complete than those for the U.S. Life-Saving Service, and the level of information recorded by various lighthouse keepers was inconsistent (Sc[illegible]ina personal communication, 1990). These materials were not examined in the course of researching this study.

4.2.1.3 Collector of Customs Casualty Reports

Beginning in 1874, casualties to merchant vessels involving loss of life or affecting the seaworthiness of a vessel were reported by law to the Collector of Customs at each vessel's home port. Each customs office kept these casualty records in handwritten bound ledgers, containing pre-printed wreck report forms. Each ledger contains approximately 180 pages. The level of detail pertaining to each casualty is high. Since the blank forms were pre-printed, there is at least one page of information regarding each casualty, and there is much consistency in the types of information reported.

The original ledgers were maintained in the office of each customs district and one copy was forwarded to the General Superintendent of the U.S. Life-Saving Service. The latter copies were used extensively when compiling the *Annual Reports* of the Life-Saving Service. A good number of these handwritten copies have survived in the National Archives in the records of the USCG. The Washington, D.C. branch of the National Archives has 19 volumes, one for Portland (1874-1903), four for Puget Sound (1884-1898), and 14 for San Francisco (1874-1898). The Seattle branch of the National Archives has four boxes of these volumes for the ports of Seattle, Portland and Astoria, dating from 1898 to the mid-1900s. The San Bruno, California, branch of the National Archives has the volumes for San Francisco dating from 1898 to 1935. For the years 1913 to 1939, the customshouse casualty reports for all of the west coast districts are on microfilm in the Washington, D.C. branch of the archives.

This is a very good source of wreck information, and a fair number of new wreck listings were located. The detailed information contained in these records makes this exceptionally useful when researching particular shipwrecks. Due to the quantity of ledgers it was not possible to search them all. A decision was made to concentrate on ledgers predating 1906, the year in which the *Merchant Vessels of the United States* volumes began to publish an annual list of vessel losses. U.S. Customs casualty reports examined when compiling the shipwreck database include all holdings from the Seattle Branch of the National Archives predating 1913 (includes the ports of Seattle, Washington, and Astoria, Oregon, for the years 1898 to 1912) and all holdings from the San Bruno Branch of the National Archives predating 1906 (includes the port of San Francisco for the period 29 August 1898 to 12 April 1906). The early volumes for Portland, Puget Sound and San Francisco contained in the Washington, D.C. branch of the National Archives have not been examined.

4.2.1.4 Steamboat Inspection Service Casualty Reports

The Steamboat Inspection Service was established by Congress in 1852 to ensure the safety of passenger steamers (Williams 1979). In 1871 the jurisdiction of the service was expanded to include all steam vessels, and by 1898, the service was responsible for the inspection of all motor vessels over 15 tons and for all sailing vessels over 700 tons. The name of this service was changed in 1932 to the Bureau of Navigation and Steamboat Inspection and again in 1936 to the Bureau of Marine Inspection and Navigation; however, the function remained essentially the same. At the outbreak of World War II, the inspecting function of the service was transferred to the USCG.

In 1946, this arrangement was made permanent when the Bureau of Marine Inspection and Navigation was abolished.

Between 1871 and 1936 the commanding officer of any vessel subject to inspection had to "report in writing and in person to the board of local inspectors nearest the port of first arrival any accident to said vessel involving loss of life, or damage to property to an approximate amount exceeding 100 dollars" (Short 1922 cited in Williams 1979). Relatively few of these casualty reports survive (Justice personal communication, 1990). The Seattle branch of the National Archives has a large quantity of these records for the Seattle office of the Steamboat Inspection Service dating from 1887-1942 (Record Group 41). A finding aid, compiled for these records by William Williams (1979), lists casualties both chronologically and alphabetically by vessel name. The original records are extensive and include many descriptions of minor damage to vessels. Unfortunately the finding aid does not contain sufficient information to determine whether vessels were totally lost or were returned to service. An examination of the original records was beyond the scope of this study.

4.2.1.5 Vessel Registries

The San Bruno, California, branch of the National Archives has an extensive collection of vessel registration records, dated from 1850 to 1910 and 1938 to 1940, for vessels homeported in San Francisco. These records were organized by the Works Projects Administration in the 1930s and are available from the National Archives on eight reels of microfilm entitled *Work Projects Administration San Francisco Ship Registry*. The vessel registries are organized alphabetically by vessel name. The types of information contained in these registries is essentially the same as that found in the *Merchant Vessels of the United States*, for example, vessel type, dimensions and hull composition, transfer of ownership, and name changes. Intermixed within the vessel registries are wreck reports recorded on standardized card forms. These records nicely complement the vessel loss tables from the *Merchant Vessels of the United States* which do not begin until the year 1906 and were published annually for the remainder of the study period. The fact that these records cover a relatively early time period made them extremely valuable to this study. All eight reels of microfilm were thoroughly gleaned for unique wreck listings.

4.2.1.6 San Francisco Marine Exchange Disaster Ledgers

This unique source is available only at the National Maritime Museum in San Francisco. It consists of a large quantity of handwritten volumes which chronicle marine casualties occurring between 1900 and 1962. Casualties of all types, ranging from minor incidents such as the loss of a spar or sail to shipwrecks resulting in the total loss of vessels, are listed chronologically. Most of the casualties occurred within the study area; however, many incidents are mentioned that occurred on the western rim of the Pacific Ocean, for example, but that involved vessels sailing from or to San Francisco. Fortunately for researchers the Marine Exchange Disaster Ledgers are indexed and were recently photographed on microfiche. The ledgers are contained on a total of 28 fiche. The index occupies another five fiche. The ledgers dating from 1900-1906, comprising approximately 40 percent of these records, were thoroughly searched for unique wreck listings during the compilation of the shipwreck database for this study.

4.2.1.7 Newspapers

Some of the best primary sources available, in terms of the detail given, are newspaper accounts. They are difficult to use, however, due to the sheer bulk of their material. Fortunately, many newspaper collections have been indexed. Some of these have subject headings specific to "vessels". Many others are indexed in the interest of genealogical research and place their primary emphasis on names and obituaries. Searching every newspaper, or even all of the indexed papers, when researching this study would have been impossible. The Portland District USCE examined several Oregon newspapers when compiling their shipwreck database, and these references have been incorporated into the MMS database. Newspaper sources utilized by EH&A in the compilation of the shipwreck database were limited to the California Information File (California State Library, Sacramento), an index of several San Francisco and Sacramento papers. A total of seven microfiche from the California Information File contain references to vessels. Some of these refer specifically to shipwrecks; however, to gain sufficient information to create a database for a particular wreck, one would need to view the source newspaper referenced in the index. A large percentage of the shipwrecks listed in the California Information File Index were already listed in the shipwreck database, thus it did not seem a productive use of time to pursue this line of research.

While the California Information File and other newspaper sources contain a great quantity of information pertaining to shipwrecks, their usefulness is best realized when researching specific shipwrecks for which the date and name of vessels are known. In order to assist future researchers in this regard, a partial list of historic newspapers covering the study area is provided at the end of this volume as Appendix C. The sources used to compile this list include bibliographic references from numerous published historic and archaeological reports, the *Lathrop Report on Newspaper Indexes* (Lathrop and Lathrop 1980), *Newspaper Indexes: A Location and Subject Guide for Researchers* (Milner 1977, 1979, 1982), and the results of a questionnaire mailed out by EH&A to major libraries in the region. Information is included in Appendix C pertaining to the temporal range of holdings, whether a newspaper is indexed, and whether the index contains subject headings for "shipwrecks", "ships", "shipping", "vessels", or "marine disasters".

4.2.2 Secondary Sources

4.2.2.1 Merchant Vessels of the United States

The U.S. government has maintained this list of registered American merchant vessels since 1868. Each vessel was assigned an official registration number by which it can be traced through time regardless of changes in vessel name or ownership. Specific information is included in this series regarding vessel ownership, tonnage, physical dimensions, propulsion systems, and type of hull construction.

Beginning in 1906, the government began to publish an annual tabulation of American vessel losses near the back of each volume. These tables are alphabetized by vessel name and include, for each vessel lost: its official registration number, type of rigging, gross tonnage, year built, souls on board, lives lost, and nature, date and place of the shipwreck. These tables, for the years 1906 to 1947, were thoroughly searched for vessel losses occurring within the study area when compiling the MMS database. Exceptions to this research include the years 1908, 1911, 1912, 1940 and 1942, for which the authors were unable to locate volumes.

4.2.2.2 Annual Reports of the United States Life-Saving Service, 1876 to 1914

The *Annual Reports* were utilized extensively during the compilation of the shipwreck database and again for statistical data on vessel loss when formulating the historic site predictive model. The *Annual Reports* should be at least partially available in all government book repository libraries, although many such libraries have incomplete sets. Most of the volumes from this series were available to EH&A when conducting this study, the only exceptions being for the years 1877, 1879, 1880, 1888, 1889 and 1891. It should be noted that only one institution, the U.S. Coast Guard Headquarters in Washington, D.C., was found to hold a complete set of these volumes (Scheina personal communication, 1990). Unfortunately, time did not permit a visit to their office. Even the U.S. Library of Congress, which was visited during the course of this study, seemed to be missing the volumes listed above.

As discussed above, the *Annual Reports* were compiled from the logbooks kept at each individual life-saving station. While these are an invaluable source, they do not mention every wreck that occurred in the vicinity of the life-saving stations. Bill Sherman, a curator with the National Archives in Washington, D.C., indicated that only those wrecks that were considered important were included in this series (Sherman personal communication, 1990). To get a totally comprehensive listing of shipwrecks witnessed by the Life-Saving Service crews, one would need to read through all of the original life-station logbooks discussed above.

Mention of specific shipwrecks can be found in three places in the *Annual Reports*. The first is entitled "Services of the Life-Saving Crew". This is a chronological table of assistance rendered to vessels during the year, including a brief description of each incident. Stations from throughout the country are mixed in this table. By 1913, this table was replaced with a short section entitled, "Some illustrative instances of rescue and salvage work performed by U.S. Life-Saving Crews", in which only a very few major wrecks were described but in greater detail than in the earlier tables.

The second place in the *Annual Reports* that lists specific shipwrecks is entitled, "Table of Casualties within the field of operations of the Life-Saving Service". The latter table is a summary of casualties to vessels and/or passengers and/or cargo to which Life-Saving Service stations rendered assistance. Although this table is easier to use, since it is arranged by life-saving district, it does not contain every incident found in the former table. For example, if a vessel stranded and was refloated with no loss of life or cargo and with no monetary damage to the vessel, it would not be mentioned in the latter table, even though the life-saving crew assisted with evacuating the vessel. Unless an incident involved monetary loss or loss of life, it was not considered a casualty. Nevertheless, knowing the distribution of such incidents provides additional information regarding the locations of areas that were prone to the occurrence of shipwrecks.

Table 64 of the *Annual Reports*, entitled "Wrecks and casualties on and near the coasts and on the rivers of the United States, and to American vessels at sea and in foreign waters, involving loss of life, during the year ending June 30,..." includes a compendium of shipwrecks and other casualties from the entire country, ordered according to the nature of the casualty (founderings, strandings, collisions, and casualties from other causes) and then chronologically within each of these divisions. This list only includes casualties involving loss of life; however, it does include vessels not found in the preceding two tables, since the information for Table 64 comes from the U.S. Customs Service. The totals for each type of casualty are summarized by geographic region in Table 65, "Summary of Wrecks and casualties..." Prior to 1913, both tables 64 and 65 indicated those casualties involving a total loss to the vessel. Beginning in 1913, however, statistics were only given for the numbers of lives lost as a result of each casualty.

A number of other useful tables can be found toward the rear of each *Annual Report*. The statistics listed in these tables were also compiled from reports received from the U.S. Customs Service. No specific vessels are named in these tables, rather they are statistical summaries of casualties to vessels. They are primarily useful for viewing trends associated with shipping and with marine casualties.

Table 66 from the *Annual Reports*, "List of places on the coast of the U.S. where vessels have stranded during the last ten years," was also of use to this study. This table lists the number of strandings occurring per year at various locations along the U.S. coastline. It is arranged by geographic region, so the Pacific placenames occur in a single section of the table. Since these statistics were compiled from the U.S. Customs Service reports, it is likely that a large number of small undocumented vessels stranded that were not included in these totals.

4.2.2.3 Annual Reports of the U.S. Coast Guard, 1915-1932

As with the *Annual Reports* of the Life-Saving Service, this series is generally available in government book repository libraries. A substantial portion of these reports, prior to 1922, are devoted to two lengthy tables. The first is entitled "Assistance rendered by cutters and stations involving the saving of life and property". The second is entitled simply "Miscellaneous Assistance". Both of these tables contain references to shipwrecks and often the final disposition of a vessel is mentioned. Locations given are usually specific within a mile or so. The tables are chronological and mix stations from the entire country. It is necessary, therefore, to scan the entire length of the tables for station numbers corresponding to the Pacific Coast. Nearly all of the tabular summaries found in the *Annual Reports* of the Life-Saving Service are ommitted from the Coast Guard reports. After 1921 the "Assistance rendered..." and "Miscellaneous Assistance" tables are no longer published. After this date, the series is of little value in researching vessel losses. *This entire series was thoroughly searched during the compilation of the shipwreck database.*

4.2.2.4 Maritime Histories

Two detailed maritime histories have been written that together cover the period of this study. *Lewis and Dryden's Marine History of the Pacific Northwest* (Wright 1895) and *The H.W. McCurdy Marine History of the Pacific Northwest* (Newell 1966) are essentially companion volumes, even though produced by different authors and publishers. *Lewis and Dryden* covers the period from earliet exploration up through 1895. The *H.W. McCurdy* volume picks up in 1896 and carries the history through 1965. They are written in similar styles with a chapter for each year, except for the very early period. There is a heavy emphasis on individuals and vessels. In other words, both histories are loaded with particulars rather than concentrating on broad trends. This fact makes them particularly useful for compiling a database of shipwrecks. Earlier researchers have cited these sources in the computerized shipwreck databases that were merged at the start of this project to form the basis for the MMS database.

4.2.2.5 Popular Publications

A large number of popular works on shipwrecks have been published that pertain specifically to various portions of the MMS study area. Most notable among these are books by Jim Gibbs, Don Marshall, Victor West and R.E. Wells. The reader is referred to either Appendix B of this volume or to Appendix B in Volume I for a more comprehensive list of the sources available. Many of these publications are indexed, making them relatively easy to compare with the database in search of new listings. As with the maritime histories mentioned above, these types of sources were utilized extensively by earlier researchers in the preparation of the computerized databases merged at the start of this study.

4.2.3 Archaeological Publications

Reports generated as the result of archaeological research are a good source of information specific to particular vessels. Cultural resource inventories are often generated as one aspect of such studies, for example: the database developed by the Portland District USCE (1985, 1987a, 1987b, 1988a, 1988b, 1989); the wreck inventory published in Delgado and Haller's (1989) cultural resource assessment of submerged federal lands along the central California coast; or the database from Pierson et al.'s (1987) cultural resource study of MMS' Southern California Planning Area. Archaeological studies often provide the best locational information available for individual vessels, since the task of matching vessel remains with vessel identity is an important aspect of assessing National Register eligibility. Whenever available, archaeological investigations of specific vessels have been referenced in the MMS database.

5.0 PREDICTIVE MODEL

A major aspect of this project has been the development of a model for predicting the locations within the study area likely to contain historic shipwrecks. Four categories of information have been utilized toward the development of this model: 1) common causes of marine disasters; 2) the distribution of environmental hazards to navigation; 3) the distribution of historic vessel traffic; and 4) the distribution of known shipwrecks.

Several premises have been assumed in the development of this model; they are listed below in the order of their relative importance. First, it is assumed that the distribution of known wrecks will best approximate the distribution of unknown wrecks. This maxim is undoubtedly most applicable in areas having a high density of known wrecks. The usefulness of the known wreck distribution for predicting locations of unknown wrecks decreases markedly, however, as one moves offshore, due to the relatively small sample of known wrecks in the offshore area and to the difficulties inherent in documenting the precise positions of these wrecks.

Second it is assumed that the density of archaeological wreck sites in a given area is directly proportional to the density of historic vessel traffic in the same area. All other things being equal, a greater proportion of wrecks should have occurred in waters where the greatest number of vessels sailed.

It is finally assumed that, density of vessel traffic being equal, a greater proportion of wrecks would occur in those areas having the most severe and/or most numerous environmental hazards to navigation. On the basis of this last assumption, common causes of vessel loss have been examined to determine the relative importance (frequencies) of vessel loss due to each of several environmental factors.

Zones of relative probabilities for the occurrence of archaeological wreck sites have been charted for the study area (Volume V) based upon a combined analysis of: 1) known wreck distribution; 2) historic vessel traffic patterns; and 3) distribution of environmental hazards to navigation. These zones have been arrived at somewhat subjectively due to the nature of the data utilized. Nevertheless, every effort has been made to objectify this model through the use of statistics for vessel loss and environmental conditions.

5.1 Types of Marine Casualties

Marine casualties are divided into several types, each of which may have one or more causes. Casualties should not be confused with shipwrecks or with total loss of vessels. Not all casualties involve shipwrecks. Nor do all shipwrecks result in the total loss of a vessel. The most common image of a shipwreck site is one in which the remains of a hull are present. Such sites form only as a result of casualties involving total loss of vessels. Archaeological shipwreck sites also may exist at locations where vessels wrecked but were later returned to service or removed for salvage, leaving behind jettisoned or lost cargo, ballast or rigging. Cargo or ballast jettisoned offshore or lost comprises a class of historic archaeological sites which need not entail the wrecking of a vessel.

The *Merchant Vessels of the United States* casualty tables classify vessel loss according to six major types of casualty: 1) Foundered; casualties due to leaking or capsizing of vessels, including vessels lost at sea not due to collision or burning, and vessels not reported after sailing; 2) Stranded; casualties due to vessels running aground, striking rocks, reefs, bars, etc., 3) Collided; collision between vessels only; 4) Burned; casualties due to fire; 5) Abandoned; abandonment at sea (but not due to age); and 6) Any other type of casualty. The U.S. Life-Saving Service *Annual Reports* list a few other types of casualties; although these are insignificant given their low frequencies.

Marine casualties are generally a matter of official record, both to establish liability for lost lives and property and to assist with efforts toward improving the safety and thus profitability of marine commerce. The *Annual Reports* of the U.S. Life-Saving Service are a useful source of such information in tabular form. The number of marine casualties, classified according to casualty type and cause, are listed by month for the years 1876 through 1914. The source of the information tabulated by the U.S. Life-Saving Service is the U.S. Customs Service casualty reports.

Tables 13 through 24 of each *Annual Report* are entitled "Abstract of returns of disasters to vessels on the Pacific coast during the year ending June 30...". The most useful of these tables for quantifying the types and causes of marine disasters are tables 14, 16, 17, 18, and 24. Table 14 lists the number of vessels totally lost during each month of the year; Table 16 distinguishes the nature of each casualty (e.g., foundered, stranded, collided, capsized, etc.) by month; Table 17 summarizes the major causes (e.g., weather-related or connected with navigation and seamanship) of founderings and strandings. Table 18 itemizes the major causes for collisions between vessels for each month of the year. Table 24 is a summary of pertinent figures from the preceding tables. The most useful statistic in Table 24, for our purposes, is the number of total losses resulting from each major type of casualty. The following discussion of marine casualties is based upon statistics gleaned from the above tables. Statistics were published in the *Annual Reports* over a 38-year period, from 1876 through 1914; however, the following summary is based upon a subset of this information. Years for which statistics were not available when calculating percentages are specified in the applicable footnotes.

The Life-Saving Service lists numerous types of casualties; however, when summarizing annual statistics, only four types are mentioned: 1) founderings; 2) strandings; 3) collisions; and 4) other. The most common type of marine casualty was stranding. Vessel strandings accounted for 39 percent of all casualties for the period 1876 through 1914[1]. Next in frequency were casualties due to collisions between vessels (32 percent) and "other" casualties (26 percent). The latter included fires (8 percent of all casualties), explosions (1 percent of all casualties), abandonment, capsizings, damage to hull, rudder and rigging, loss of sails, masts and anchors, leaking vessels, striking of wharves, loss of deck loads, or any other conceivable type of damage that a vessel could incur. Founderings accounted for only 3 percent of all casualties.

The fact that the Life-Saving Service bothered to itemize founderings separately from "other" indicates that founderings were not minor incidents. Although founderings occurred infrequently and account for a relatively small proportion of archaeological wreck sites (approximately 6 percent), to have one's vessel founder was the surest way to lose the vessel. Based upon Life-Saving Service statistics[2], 54 percent of all vessels that foundered were totally lost. By comparison: 46 percent of all strandings resulted in a total loss of the vessels involved; only 5 percent of collisions resulted in a total loss to one of the vessels, while 24 percent of "other" causes resulted in a total loss of the vessels. One can see from the above statistics that both founderings and strandings were casualties that placed vessels at great risk. Strandings, by lieu of the fact that they occurred much more frequently than founderings, accounted for a much larger proportion of shipwrecks.

For the period from 1876 through 1914[1], a total of 3,134 casualties were reported from the United States Pacific coast. Of this number, 888 vessels were declared a total loss. From these figures we can see that 28 percent of marine casualties resulted in the total loss of vessels, while 72 percent of all marine casualties resulted in only partial damage to the vessels. Breaking the above 28 percent for total losses down by type of disaster[2], we find that: 17 percent of all marine casualties resulted in a total loss by stranding; 2 percent of all casualties resulted in total loss by foundering; 2 percent of all casualties resulted in total loss by collision; and 7 percent of all casualties resulted in a total loss by miscellaneous other agents.

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[1] Excluding the years 1877, 1879-80, 1888-89, 1892 and 1894.

[2] Based upon 24 out of 38 total years; missing data for years 1876-77, 1879-89, 1899 & 1904.

The casualty and loss statistics published by the U.S. Life-Saving Service are not sufficiently detailed to allow estimates for the number of archaeological sites likely to contain only cargo and/or ballast, anchors, rigging, etc. For this reason, only statistics regarding total loss are utilized in this analysis of shipwreck causes and wreck site distribution. Total losses correspond approximately to the population of vessels that exist as archaeological sites. The number of archaeological shipwreck sites containing hull remains is undoubtedly less than the number of total losses due to the removal of some vessels for salvage purposes. The number of historic archaeological sites associated with ships and shipwreck events is probably much greater than the number of total losses to vessels. The estimated proportion of losses resulting from each major type of casualty has been calculated from U.S. Life-Saving Service statistics with the following results[2]: 63.7 percent of all total losses were by stranding; 5.8 percent of all total losses occurred by foundering; 6.0 percent of all total losses occurred as a result of collisions between vessels; and 24.5 percent of all total losses occurred by miscellaneous other agents.

From the above statistics we can deduce something regarding the probable distribution of archaeological wreck sites. For example, we would expect 64 percent of all wreck sites (site as used here implies archaeological site containing hull remains) to occur on or in immediate proximity to the shoreline, since all strandings necessarily occur in the vicinity of the shoreline. As we shall see below, the major causes for founderings are high winds and heavy seas, thus we would expect slightly less than 6 percent of all wrecks to occur in unprotected offshore waters. The percentage of foundered vessels that later drifted ashore cannot be easily estimated, although this certainly occurred. Those that did not drift ashore or that were not towed ashore, presumably sank offshore.

Collisions to vessels are most likely to occur in high-traffic areas having frequent poor visibility. Both of these criteria imply that most sinkings due to collisions between vessels would have occurred in harbors and/or constricted sealanes and channels. The exact proportion of vessels lost in these settings versus offshore, due to collisions, cannot be easily estimated; however, it is suspected that very few vessels collided outside of harbors and harbor approaches. One exception might be in the vicinity of headlands where vessel traffic would be concentrated within a relatively narrow sealane due to the tendency to cut corners around headlands when navigating the inside coastal routes. We might estimate the percentage of sinkings in the vicinity of harbors and headlands combined, due to collisions between vessels, to be slightly less than 6 percent of all wreck sites, with the majority of these being concentrated in or near harbors.

Twenty-four percent of all total losses occurred by "other" means, the locations of which are less predictable. For example, loss by fire or by explosion might occur with equal frequency at sea or in a harbor. The majority of abandonments and capsizings probably occurred at sea; however, the percentage of such vessels that sank at sea can only be guessed. Many undoubtedly drifted or were towed ashore. Loss by leaking probably occurred far enough offshore so that the captain could not make shore to run the vessel aground, but the percentage of vessels lost in this manner is small.

5.2 Causes of Marine Casualties and Losses

We now know something of various manners in which vessels were commonly wrecked and lost in the study area. Next let us examine some of the most common causes for marine casualties and losses. The U.S. Life-Saving Service lists four major categories of cause: 1) causes connected with weather; 2) causes connected with navigation and seamanship; 3) causes connected with machinery or boilers; and 4) other causes. A number of inconsistencies were noted by the author in the way various causes were categorized in the Life-Saving Service tables, for example, darkness is generally listed as a weather-related cause; heavy seas were sometimes listed as weather-related and sometimes listed as "other;" and involvement with ice was generally listed as "other" when it could justifiably be classified as weather-related. The Life-Saving Service itemized causes for collisions in a separate table, and these were not even broken down into the above categories.

In order to maintain consistency when analyzing the Life-Saving Service statistics, the author slightly modified their categories for cause to include: 1) Weather-related. This includes: high winds; heavy seas; calms, currents and/or tides; low visibility due to fog; and miscellaneous weather-related (the latter including ice, lightning, snowstorms, etc.); 2) Human error. This includes: errors of pilots, master, officers and crew, "fault of other vessel", "bad management", "error in judgement", "misunderstanding signals", and "fault of tug towing"; 3) Equipment-related. This includes: damage to machinery and/or rigging, explosion of boiler, defective chart, and defective compass; and 4) Other causes. This includes: fire, leaks, striking sunken rocks, darkness, miscellaneous, and unknown causes. The relative importance (frequency) of each category in contributing toward each major type of marine casualty is illustrated in Figure IV-12.

The total numbers of casualties and losses for each category above have been tabulated from the U.S. Life-Saving Service *Annual Reports*. From these statistics, the frequency of archaeological wreck sites resulting from each cause has been estimated for each major type of casualty (tables IV-2 and IV-3). Two sets of frequencies have been calculated for each combination of casualty type and cause. The first (Table IV-2), indicates the frequency of casualties resulting in a total loss to a vessel, by type and cause of disaster. For example, 4.9 percent of all casualties resulted in a total loss to a vessel by stranding due to high winds. These frequencies have been included both for comparison with the estimated frequency of total losses resulting in wreck sites from each cause and for use by future researchers. If accurate statistics could be assembled for total vessel traffic on the Pacific coast during the period 1876 to 1914, actual probabilities could be calculated for the chances that any particular vessel would end up a total loss due to any or all causes. From such figures we could more precisely estimate the total number of archaeological wreck sites for other periods simply by knowing the volume of vessel traffic for the period in question.

The second set of frequencies, listed in Table IV-3, is the estimated maximum percentage of total losses resulting in archaeological wreck sites due to each cause. The latter figures are the most useful for the development of our predictive model.

The results of the above analysis show that weather-related causes accounted for 50 percent of all marine casualties (Figure IV-12) and 55 percent of all total losses (Table IV-3) reported by the Life-Saving Service between 1876 and 1914[1,3]. Weather is followed in frequency by miscellaneous "other" causes (31 percent of all casualties; and 31 percent of all total losses), then by human error (14 percent of all casualties; 8.2 percent of all losses), and finally by faulty equipment (5 percent of all casualties; 5.9 percent of all total losses).

The usefulness of the latter three categories of cause for predicting the likely distribution of wreck sites is questionable. With the exception of abandonment and capsizing, neither of which is really a cause and both of which would often be weather-related, "other" causes might be expected to act indiscriminately (with equal frequency) on vessels, regardless of location.

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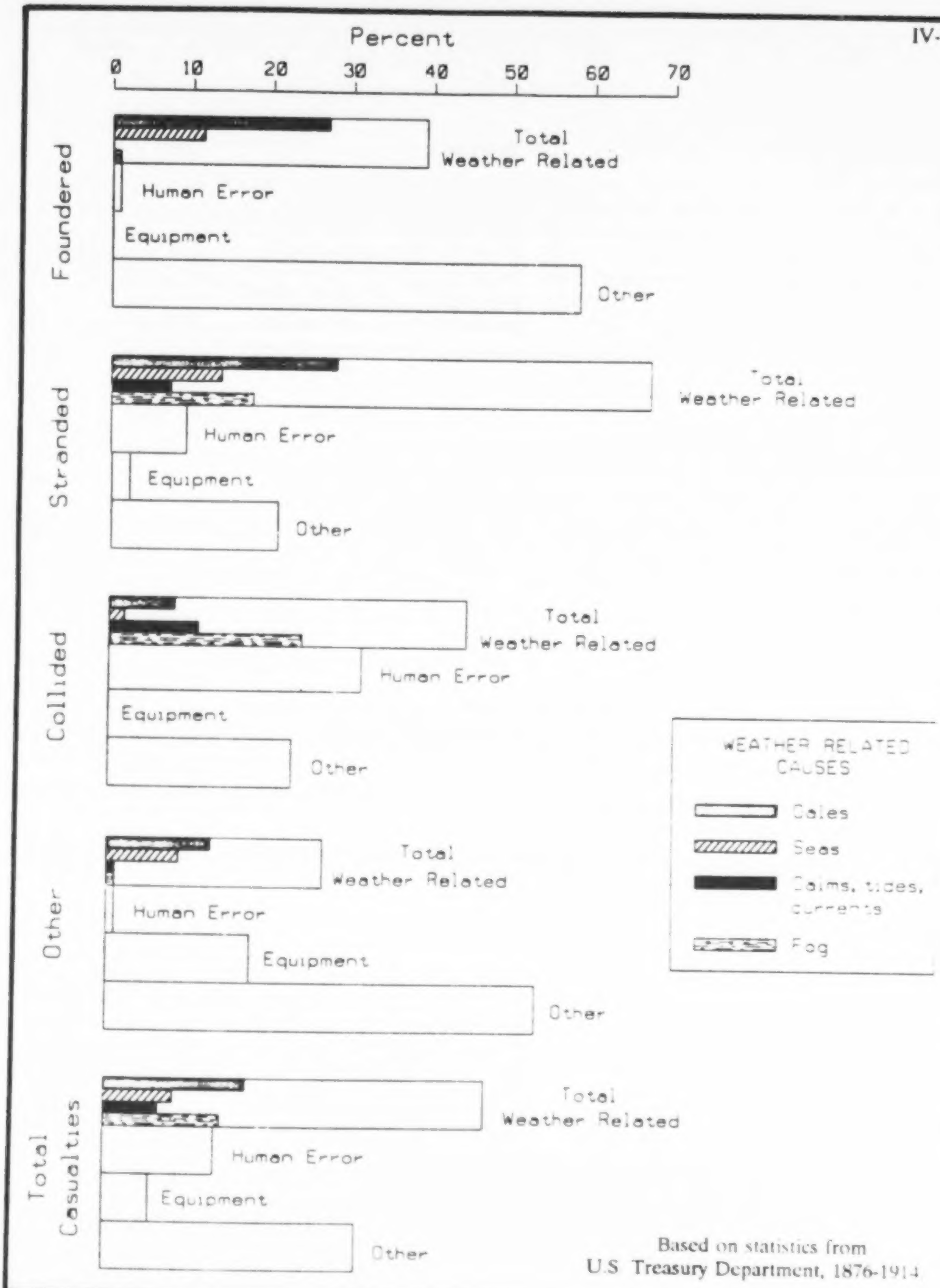
[3] Prior to the age of steam, the percentage of weather-related casualties was higher. As steam- and gas-powered engines became more prevalent, the percentage of weather-related casualties decreased due to the increase in casualties resulting from fires and from boiler explosions and to the increased ability to maneuver in adverse weather conditions.



Based on statistics from
U.S. Treasury Department, 1876-1914

Figure IV-12. Relative Frequencies (%) of the Most Common Causes for Marine Casualties.

TABLE IV-2

ESTIMATED FREQUENCY (%) OF CASUALTIES RESULTING IN ARCHAEOLOGICAL SHIPWRECK SITES FROM ALL CAUSES[*]

Cause	Casualty Type Foundered (54.1)[**]	Stranded (45.7)	Collided (5.4)	Other (23.7)	Total
High Winds	0.4	4.9	0.1	0.9	6.3
Heavy Seas	0.2	2.4	0.03	0.6	3.2
Calms, Currents, Tides	—	1.3	0.2	0.07	1.6
Fog	0.02	3.1	0.4	0.07	3.6
Misc. Weather	—	—	—	0.2	0.2
Total Weather-Related	0.6	11.8	0.8	1.8	15.0
Equipment-Related	—	0.4	—	1.2	1.6
Human Error	0.02	1.6	0.5	0.07	2.2
Other	0.9	3.7	0.4	3.6	8.6
Total	1.6	17.4	1.7	6.7	27.3

[*] Based on statistics from U.S. Treasury Department, 1876-1914.

[**] Numbers in parentheses ( ) indicate percentages of each casualty type resulting in total losses. For example 54.1% of all founderings resulted in a total loss of the vessel.

Explanatory Note: Given 100 casualties, the estimated frequencies suggest that only 27.3 (see totals) would result in archaeological shipwreck sites (the actual number of wreck sites remaining today would be lower due to removal of some wrecks for salvage). Of these same 100 casualties, 0.4% were lost by foundering in high winds; 4.9% were lost by stranding due to high winds, and so on.

TABLE IV-3

ESTIMATED FREQUENCY (%) OF ARCHAEOLOGICAL SHIPWRECK SITES RESULTING FROM ALL CAUSES*

Cause	Casualty Type				Total
	Foundered	Stranded	Collided	Other	
High Winds	1.6	18.1	0.5	3.2	23.4
Heavy Seas	0.7	8.9	0.1	2.2	11.9
Calms, Currents, Tides	---	4.8	0.7	0.2	5.7
Fog	0.1	11.4	1.4	0.2	13.1
Misc. Weather	---	---	---	0.7	0.7
Total Weather-Related	2.4	43.1	2.7	6.6	54.8
Equipment-Related	---	1.5	---	4.4	5.9
Human Error	0.1	6.0	1.9	0.2	8.2
Other	3.4	13.4	1.4	13.2	31.4
Total	5.8	63.7	6.0	24.5	100

Explanatory Note: The percentages above are derived from those in Table IV-2 by dividing each of the latter by 27.3 (the total from Table IV-2), then multiplying by 100%.

* Based on statistics from U.S. Treasury Department, 1876-1914.

Likewise, both human error and equipment failure are unpredictable. They could occur anywhere at anytime.

Weather, on the other hand, is variable and predictable. The frequency of severe weather conditions that would likely contribute to marine disasters varies both geographically and seasonally (see discussion in Section 5.3). For example, thick fog and high winds are more common during certain months than during others. Likewise, such conditions are more common along certain sections of the coast than along others. The predictable nature of weather-related causes has been utilized extensively in formulating our predictive model for vessel loss. The precise role of weather in the predictive model is discussed in detail in Section 5.6. For now let us discuss the relative importance of weather-related causes within the four major categories of marine casualties: founderings, strandings, collisions and other.

Strandings. Sixty-eight percent of all strandings are caused by weather. This compares with 21 percent by "other" causes, 9 percent due to human error, and 2 percent due to faulty equipment. Weather-related causes of strandings can be broken down further into the individual types of weather-related causes mentioned above (Figure IV-12): 28 percent are caused by high winds; 14 percent are caused by heavy seas (usually associated with high winds); 8 percent of all strandings are caused by a combination of calm winds, tides and currents; and 18 percent of all strandings are caused by fog.

Strandings are estimated to account for 63.7 percent of all total losses (Table IV-3). If we assume that weather-related causes are responsible with equal frequencies for total versus partial losses, then we can estimate that strandings caused by weather account for 43.1 percent of all total losses. The balance of total losses resulting from strandings were caused by other less predictable factors.

The above figures have been applied to the historic site predictive model as explained by Table IV-4. At least 64 percent of archaeological wreck sites can be expected to occur in the nearshore zone[4] (i.e., stranded). If 43 percent of archaeological wreck sites occurred within this zone due to weather-related causes (compare tables IV-3 and IV-4), then 21 percent of all archaeological wreck sites should occur in the nearshore zone without regard to the distribution of severe weather conditions (i.e., wreck distribution should primarily reflect density of vessel traffic; Table 5-3). One can see from tables IV-3 and IV-4 that high winds are the primary cause of weather-related losses in the nearshore zone. Low visibility due to fog is secondary to wind in this regard.

If we could accurately factor into this equation the density of vessel traffic along various coastal segments, then we might arrive at fairly realistic probabilities for the occurrence of wreck sites in the nearshore zone. Relative traffic densities have been surmised, however, as described in Section 5.4. Exceptional high-traffic areas near harbors are considered independently of both weather-related factors and the locations of shipping lanes when assessing relative probabilities for vessel loss.

Collisions. Forty-five percent of all collisions are caused by weather (Figure IV-12), as compared with 32 percent due to human error and 23 percent due to "other" causes. The most common weather-related cause of collisions is fog (24 percent), followed by tides and currents (11

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[4] For the purpose of discussion, the nearshore zone should be considered as that area having a water depth that would allow a vessel to contact the bottom while floating at the base of the deepest of storm-wave troughs. The width of this zone out from the shoreline varies with the bottom topography. It also varies for vessels having different drafts. To be both practical and conservative, we have defined the nearshore zone as the area located between the shoreline and the 10-meter isobath. In reality, the majority of strandings have occurred closer to shore than this, while very deep-draft vessels could conceivably strike bottom in deeper water during extremely heavy seas.

TABLE IV-4

EXPECTED GEOGRAPHIC DISTRIBUTION OF ARCHAEOLOGICAL SHIPWRECK SITES IN THE STUDY AREA*

	Casualty Type				
	Foundered	Stranded	Collided	Other	Total
Primary/Secondary Weather Factors Contributing to Vessel Loss (from Figure IV-12)	Wind/Seas	Wind/Fog	Fog/Calm, Currents, Tide	Wind/Seas	
Percentage of Weather-Related Vessel Losses	2.4	43.1	2.7	6.6	54.8
Percentage of Vessel Losses Only Traffic-Dependent	3.4	20.6	3.3	17.9	45.2
Estimated Percentage of Shipwreck Sites Resulting From Vessels Which:	5.8	63.7	6.0	24.5	100
Geographic Distribution					
Harbors/Harbor Approaches (Primarily Traffic-Dependent)	3.4	N/A	<6.0	<17.9	3.4-27.3
Nearshore Zone	N/A	63.7	<6.0	<17.9	63.7-87.6
Offshore (Primarily Weather-Related)	2.4	N/A	N/A	6.6	9.0

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* Based on statistics from U.S. Treasury Department, 1876-1914.

percent) and "high and baffling winds" (8 percent). Two percent of all collisions are attributed to heavy seas.

Despite their relatively high frequency of occurrence, collisions account for only 6 percent of vessel losses. Even fewer vessels are lost by collisions due to weather (2.7 percent). Half of these (1.4 percent of all vessel losses) occur under low visibility conditions. Collisions caused by a combination of calms, currents and tides account for 0.7 percent of all losses, as compared to 0.5 percent for collisions due to high winds. Secondary to vessel loss by weather-related collisions is vessel loss from collisions due to human error. The latter was responsible for 1.9 percent of all vessel losses.

It is likely that most losses by collision occur in or near harbors since these areas have the highest density of vessel traffic. One can surmise from Table IV-4 that the distribution of losses by collision is more traffic-dependent than weather-dependent. On this basis alone, the greatest number of collisions would be expected in the vicinity of harbors. Looking at the most common weather-related causes of collisions, one can see that the majority occur under conditions of low visibility and/or calm winds. Both of these weather phenomena are, by far, more prevalent near the coast than offshore. It seems likely then that very few collisions would have occurred offshore.

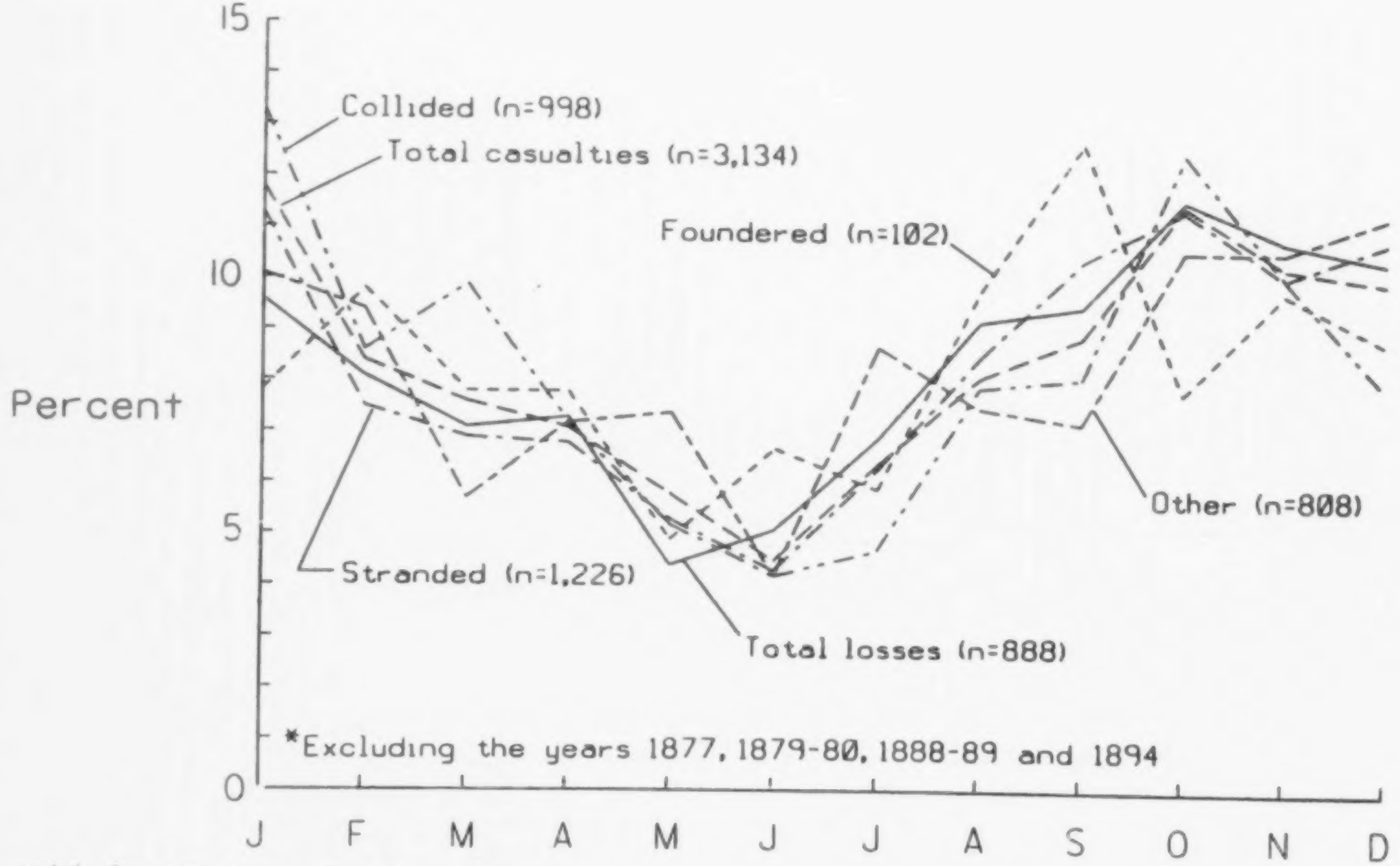
Founderings. Forty percent of all founderings are caused by weather (Figure IV-12), as compared with 59 percent due to "other" causes and 1 percent due to human error. High winds are the most common weather-related cause of founderings (27 percent), followed by heavy seas (12 percent) and fog (1 percent).

It is estimated that founderings accounted for 5.8 percent of all vessel losses (Table IV-3). Weather-related founderings accounted for 2.4 percent of all losses, while 3.4 percent resulted from "other" causes having a more traffic-dependent geographic distribution (Table IV-4). The most significant weather factors contributing to founderings are high winds and heavy seas. Both of these phenomena occur with highest frequencies offshore, thus one would suspect that nearly all weather-related founderings occurred offshore but in high traffic sealanes (Table IV-4). The distribution of wreck sites due to foundering from "other" causes is most likely to reflect the distribution of vessel traffic, that is, occurring in the vicinity of harbors and high density shipping lanes.

Other Casualties. Twenty-seven percent of casualties in this category are due to weather-related causes (Table IV-3). Of this number, 13 percent are due to high winds and 9 percent to heavy seas. Fog, calms, tides and currents play a rather insignificant role within this category. The majority of "other" casualties (54 percent) are due to "other" causes, while 18 percent are caused by faulty equipment and 1 percent by human error.

It is estimated that other casualties accounted for 24.5 percent of all vessel losses (Table IV-4): 6.6 percent of all losses resulted from "other" casualties having weather-related causes; 17.9 percent of all losses resulted from "other" casualties having non-weather-related causes. The most common weather factors contributing toward "other" casualties are high winds and heavy seas, suggesting an offshore distribution of weather-related wreck sites in this category and a nearshore and/or harbor vicinity distribution for wrecks resulting from non-weather-related causes (Table IV-4).

The strong relationship between weather and marine casualties/losses is immediately obvious when one examines the monthly frequencies of each major type of casualty (Figure IV-13). Notice first of all the distribution of total casualties as compared to total losses. For the most part, their monthly frequencies closely approximate one another with the lowest frequencies of both occurring from April through July and the highest frequencies of both occurring from October through January. These two curves compare favorably with the annual trends in hazardous weather conditions discussed in Section 5.3.



Based on statistics from U.S. Treasury Department, 1876-1914.

Figure IV-13. Monthly Frequency (%) of Marine Casualties & Losses by Type of Casualty, 1876-1914.

The only major discrepancy between the two curves occurs in January when total casualties peak for the year while total losses continue a steady decline from their October peak. This phenomenon is due to a combination of two factors: 1) the annual high for collisions occurs during the month of January pulling the total number of casualties upward with little corresponding effect on total losses (collisions accounted for only 6 percent of all total losses as opposed to 39 percent of all casualties); and 2) at the same time "other" casualties decline pulling the total loss curve downward.

The curves for each major type of casualty in Figure IV-13 also closely follow the seasonal weather trends discussed in Section 5.3. Monthly frequencies for high winds, heavy seas and low visibility are presented in Section 5.3 in a format similar to that of Figure IV-13. A close comparison of Figure IV-13 with these weather frequency distribution curves will provide the reader with a sense of the strong correlation between weather and vessel loss. Bear in mind the frequencies from Figure IV-12 and Table IV-3 describing the relative importance of each weather factor in contributing toward the various types of marine casualties and vessel losses, when drawing the above comparisons. Of all the curves in Figure IV-13, the curve for strandings should best approximate weather trends, since 67.7 percent of all strandings are weather-related (Figure IV-12) as opposed to 45 percent for collisions, 39.6 percent for founderings, and 27 percent for "other" casualties. The curve for founderings may be unreliable due to the small sample involved (n=102).

Notice in Figure IV-13 that the curve for strandings continues on an upward trend between August and September while collisions level off over the same period. High winds are the biggest factor contributing to strandings, yet September has the lowest average wind velocity of the year for the study area. How do we explain the rise in strandings during the month of September? The month of September happens to be one of the foggiest of the year for the study area. Looking at Figure IV-12, we see that fog is the second-most important factor contributing to strandings, being responsible for 18 percent of all such casualties. Fog is also an important factor in causing collisions; however, it is sufficiently overshadowed by non-weather-related human error and "other" causes that collisions do not increase during September.

5.3 Environmental Factors Affecting Vessel Loss

In the previous section, the roles that various environmental factors played in causing marine casualties and losses were quantified. It has been established that as many as 54.8 percent of all shipwrecks resulting in a total loss to the vessel were caused by factors in the physical environment. These factors have been referred to, after the fashion of the U.S. Life-Saving Service, as weather-related causes. The purpose of the following discussion is to characterize the geographic distribution of these environmental factors across the study area.

Those weather-related factors having the most significant impact upon shipping and vessel losses include, in descending order of importance (from Table IV-3): 1) high winds (responsible for approximately 23.4 percent of all vessel losses); 2) fog (13.1 percent of all losses); 3) heavy seas (11.9 percent of all losses); and 4) calms, currents and/or tides (5.7 percent of all losses). Miscellaneous weather factors (such as involvement with ice or low visibility due to snowstorms) were responsible for approximately 0.7 percent of all losses.

One can see from the above statistics that wind is by far the dominant environmental factor responsible for vessel losses. Realizing that heavy seas occur as a result of, and generally (though not always) simultaneously with, high winds, the significance of wind in contributing toward vessel losses becomes even more pronounced. The incidence of fog is very obviously secondary to wind as a cause of vessel loss, although it is certainly not insignificant. Calm conditions are the least significant of weather factors resulting in vessel loss.

The remainder of Section 5.3 is a summary of average climatic conditions for the study area. The purpose of this discussion is to demonstrate the degree of variability of average annual weather conditions across the study area. All weather factors vary significantly with season; however, unless the average annual state of a particular factor varies geographically, that factor has little predictive value in determining areas of high versus low probability for marine casualties and vessel loss.

The following discussion of the study area's physical environment has been synthesized from a recently published climatic atlas entitled *U.S. Navy Regional Climatic Study of the Northern California Operating Area* (U.S. Department of Commerce (USDC) 1988). This volume contains detailed monthly climatic and sea-state summaries collected from shipboard observations taken between 1854 and 1985. The majority of the observations were made during the last 30 years, thus the level of information gathered is generally consistent. USDC (1988) presents various types of climatic summaries in chart form for the entire MMS study area. The information is tabulated or charted in 1-minute blocks, corresponding to a one-quarter quadrant of each MMS map unit. The use of the tabulated weather data contained in USDC (1988) makes it possible to characterize the average monthly conditions for the period of record with great detail. A brief textual summary of overall dominant characteristics and patterns prefaces the volume.

Another reliable and important source of charted weather and sea-state information is a climatic atlas entitled *Climatic Study of the Near Coastal Zone, West Coast of the United States* (USDC 1976). The latter volume contains much of the same types and level of information as does USDC (1988). Both volumes are available to the public from the National Climatic Data Center in Asheville, North Carolina.

5.3.1 General Climate

The U.S. Department of Commerce and Labor (USDCL) briefly characterized weather conditions along the Pacific coast in their U.S. Coast Pilot publication series. The weather information contained in these volumes was very general and could do little more than provide a captain, unfamiliar with the area, with an idea of weather extremes that might be encountered during a particular season. An excerpt from the Pacific Coast Pilot for 1903 follows.

> Weather. - There are two seasons - the summer or dry season, which begins about May and continues until October, and the winter or rainy season, covering the remainder of the year. These seasons vary in length in different parts of the coast as well as in different years.
>
> In the southern part of the coast [including southern California] the rainy season is comparatively short and the rainfall much lighter than in the northern portion, being so light in some years as to cause considerable damage to the stock and farming industries. The winter gales from southward and southwestward are less frequent and less severe than at more northern points. The temperatures are milder and more even, and the snowfall is limited to the higher mountain peaks.
>
> Northward of San Francisco the rainy season increases in length and the amount of rainfall, and as Juan de Fuca Strait is approached showers of short duration and generally local may be looked for at any time. Snow falls at rare occasions in San Francisco and vicinity, but is frequent and at times heavy in the vicinity of Juan de Fuca Strait. From San Francisco northward the winter gales increase in severity, frequency, and duration, while in summer the northerly and northwesterly winds at times reach almost hurricane strength (USDCL 1903).

The weather and surface currents of the study region are driven by two large-scale, semi-permanent atmospheric systems. During the summer the North Pacific Subtropical High dominates the entire northern Pacific Ocean (Figure IV-14). This system is responsible for the prevailing northwestly winds during the summer, that help to drive the southeasterly-trending California Current. In the winter, this high-pressure system is displaced to the southern portion of the study area by a large region of low pressure that dominates the northern Pacific allowing movement of storm systems into the study area on a more frequent basis.

5.3.2 *Surface Winds*

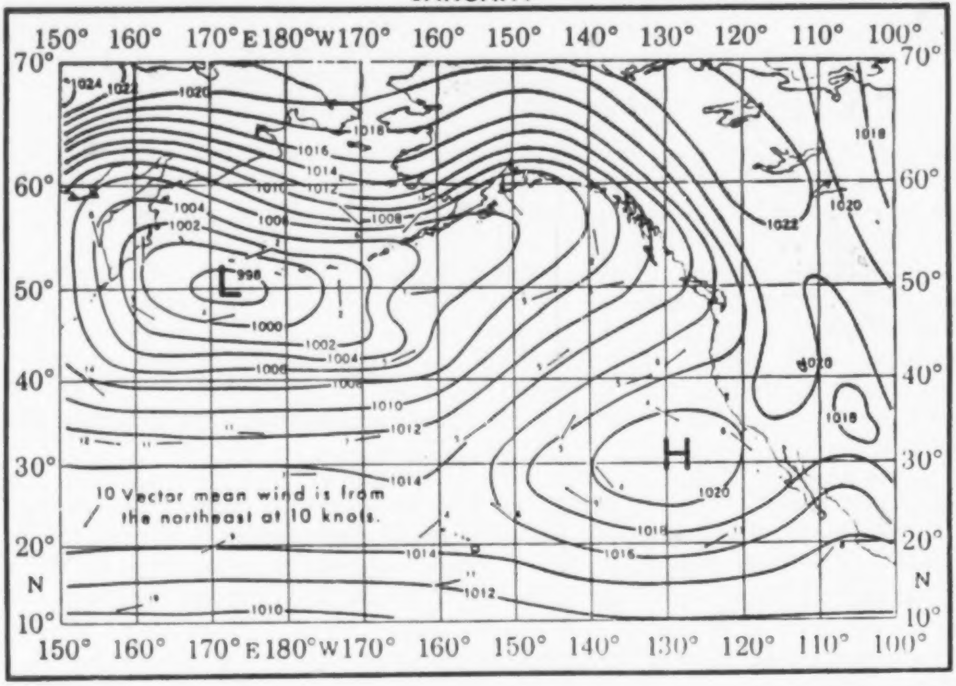
The seasonal variation in the size and location of the North Pacific Subtropical High results in a seasonal shift in the prevailing winds of the study area. During the summer months the subtropical high dominates the entire northern Pacific resulting in relatively consistent northwesterly winds along the U.S. Pacific coast. As low pressure descends on the northern Pacific during the winter months, surface winds from central California northward are much less predictable due to the effect of storm systems periodically sweeping into the area. Winter winds near the coast tend to blow from the south along the Oregon and Washington coasts and from the northwest along the central California coast. Winter winds along the northern California coast, between 40 and 42 degrees north latitude, are variable in direction depending upon the strength and location of the subtropical high during any given winter. Winds remain northwesterly offshore of central California during the winter months. In northerly latitudes of the study area, winter winds are more variable in direction due to the frequent influence of low pressure systems. Generally speaking, coastal winds in any season prevail in a direction parallel to the heading of the local coastline.

The Pacific Coast Pilot for 1903 characterized winds of the study area as follows:

> **Winds.** - The prevailing winds in summer are from northwest, west, and southwest; on the southern part of the coast the westerly and southwesterly winds prevailing. The northwest winds in summer frequently reach a velocity of 70 miles an hour and extend as far south as Point Conception, eastward of which their severity is much less. As a rule, the northwest wind begins about sunrise and reaches its maximum velocity about 3 or 4 p.m., moderating toward sunset and dropping to light airs or calms by daylight. The severe northwesterly gales generally last two to three days and continue throughout the night with little or no diminution.
>
> In winter the heaviest weather is from southeast and southwest, with an occasional northerly gale of short duration. The southeast gale occurs at any time, generally accompanied by rain and thick weather, and increasing in severity northward. These gales, with the heavy southwest swell prevailing during the winter months, cause a confused, irregular sea that taxes the weatherly qualities of a vessel to their utmost (USDCL 1903).

5.3.2.1 Frequency of Strong Winds

Two categories of strong wind speeds are summarized here: winds having a velocity ranging from 22-33 knots and gale-force winds having a velocity of 34 knots or greater. In general, JANUARY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10 Vector mean wind is from the northeast at 10 knots.

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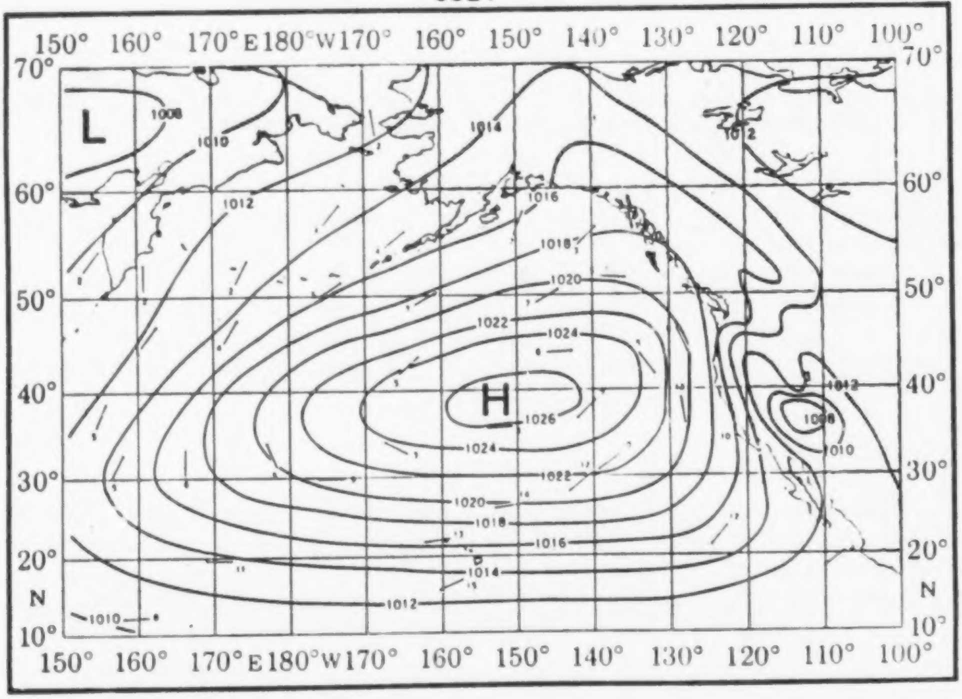
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Based on U.S. Department of Commerce, 1988

Figure IV-14. January and July Mean Sea Level Pressure and Vector Mean Winds.

wintertime high winds (greater than or equal to 22 knots) occur most frequently north of Cape Mendocino (located approximately 41 degrees north latitude), peaking in December. Summertime high winds occur most frequently offshore of and south of Cape Mendocino, peaking in June and July. Winds offshore are invariably higher than near the coast at any season of the year.

The highest frequency of strong winds in the southern half of the study area occurs in the area offshore of Cape Mendocino and Point Arena where gale-force winds occur with a peak summertime frequency of 7 percent during the month of June (Figure IV-15), an average of just over two days per month. Winds ranging from 22-33 knots peak in frequency for the southern half of the study area during the month of July (Figure IV-15) with the highest frequency, 30 percent (one out of every three days), again occurring in the offshore area between Cape Mendocino and Point Arena.

The frequency of strong winds lessens in the southern half of the study area from July to September. The period of fewest high winds for this area is, ironically, from October through February. By this time of year, the frequency of strong winds begins to increase in the northernmost portion of the study area. As low pressure invades the northern Pacific, storm systems with associated high winds begin to encroach into the area from the northwest. In December the frequency of winds over 22 knots peaks for the entire study area north of Cape Mendocino (Figure IV-16). During this month, gale-force winds occur near the coast with a frequency of 4-5 percent north of Cape Mendocino and 2-4 percent south of there. Offshore gale frequency in December averages 9 percent off of the Washington and Oregon coasts, the highest for the year in any portion of the study area.

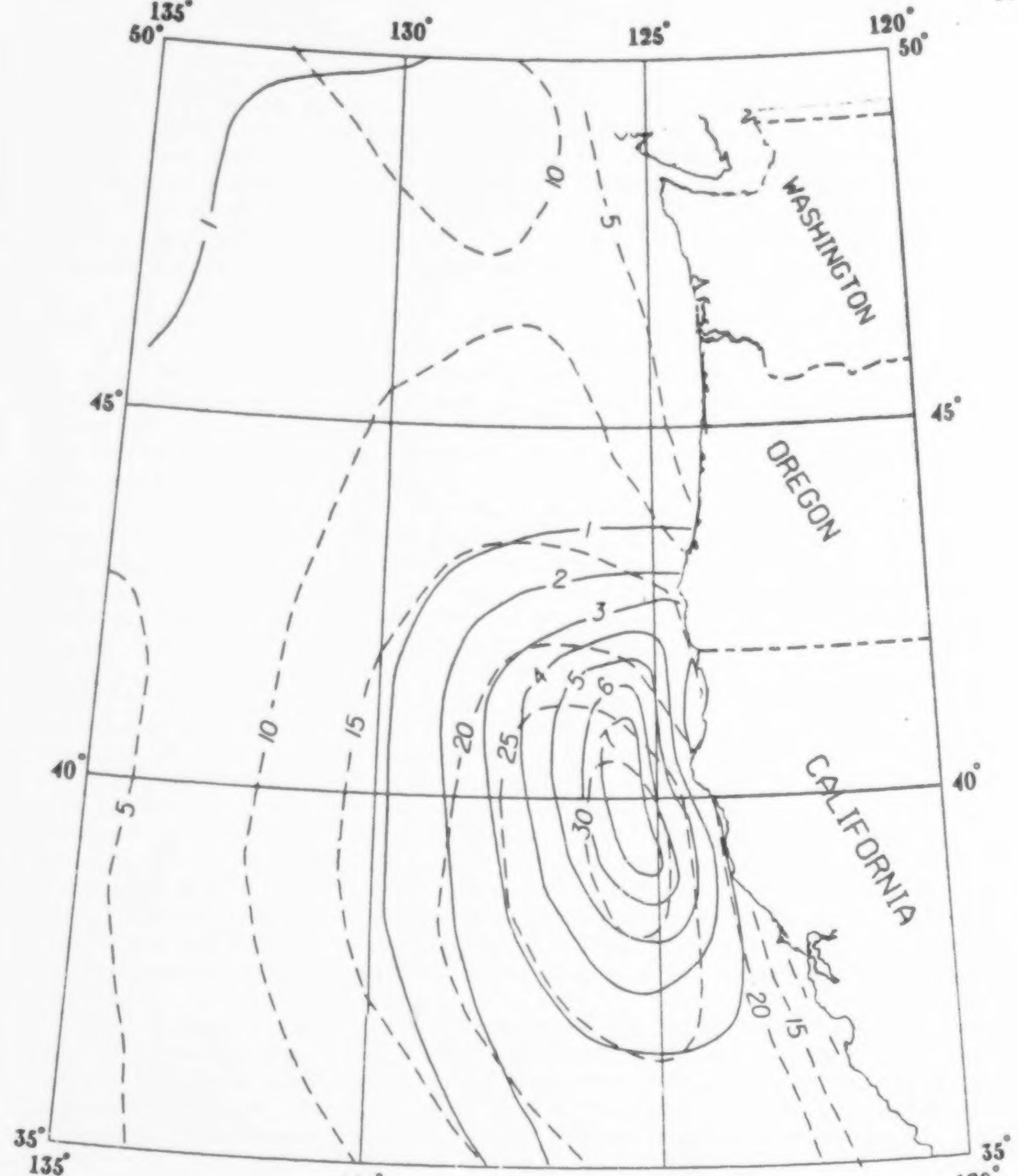
The frequency of strong winds decreases only slightly during the month of January. Throughout February and March strong wind frequencies gradually decrease across the entire study area. By April the frequency of strong winds drops off markedly in the northern half of the study area and near the coast in all areas. April resembles the month of September somewhat in the distribution of winds over 22 knots. At the same time that high wind frequencies decrease in the northern half of the study area, they begin to increase during the month of April offshore between Cape Mendocino and Point Arena, finally reaching their highest frequency of occurrence again during the month of June.

Thunderstorms are rare in the study area and are usually not severe. Changery (1981 cited in USDC 1988) indicates a frequency of less than 5 thunderstorms per year in western California, south of Cape Mendocino, and a frequency of less than 10 per year north of there. Tornadoes are even less frequently sighted offshore within the study area. Waterspouts along the west coast are most often seen off of southern California.

5.3.2.2 Calm Conditions

The surface wind rose charts in USDC (1988) list the average frequency of calm conditions for every degree of latitude and longitude in the study area and for each month of the year. The primary danger of calm wind is that it might occur simultaneously with heavy seas caused by offshore winds or by a preceding storm. We need only be concerned with the frequency of calm winds in the nearshore environment, where ships might be pushed aground by a heavy swell.

As might be expected, the frequency of calm winds is inversely related to the frequency of strong winds. During the winter months, when strong winds predominate north of Cape Mendocino, the highest frequency of calm in the nearshore area occurs south of Cape Mendocino (7.7 percent, as opposed to 5.0 percent in the north). During the summer months, when winds are highest in the southern portion of the study area, calm air is more prevalent along the coastline to the north (7.1 percent, as opposed to 5.2 percent in the south). When one compares the frequencies of calm winds during the course of the entire year in the north with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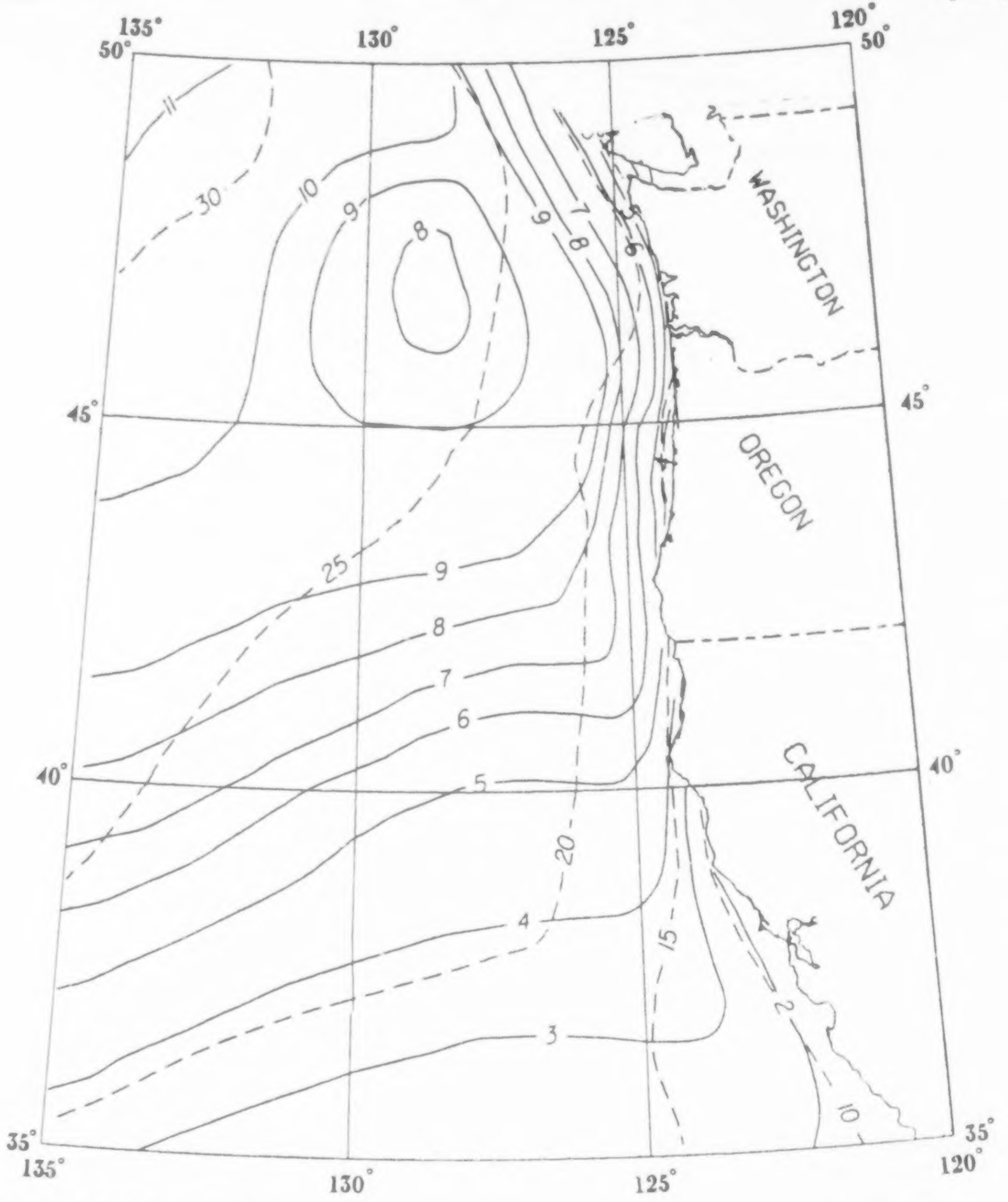
Percent Frequency of:

- - - - Wind Speed 22-33 Knots, July

——— Wind Speed ≥ 34 Knots, June

Contours from U.S. Department of Commerce, 1988

Figure IV-15. Peak Summertime Wind Events.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OREGON
CALIFORNIA
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8
7
6
5
4
3
2

Percent Frequency of:

- - - - Wind Speed 22-33 Knots, December

——— Wind Speed ≥ 34 Knots, December

Contours from U.S. Department of Commerce, 1988

Figure IV-16. Peak Wintertime Wind Events.

those in the south, there is very little overall difference. North of 41 degrees latitude, it is calm approximately 6.1 percent of the time (22 days out of the year), while south of 41 degrees, it is calm 6.5 percent of the time (24 days out of the year). Given the relative insignificance of calms for contributing toward vessel loss, this slight geographical variation should have little effect on the number of vessel losses occurring in the north versus the south, hence the average distribution of calm conditions has a relatively low predictive value.

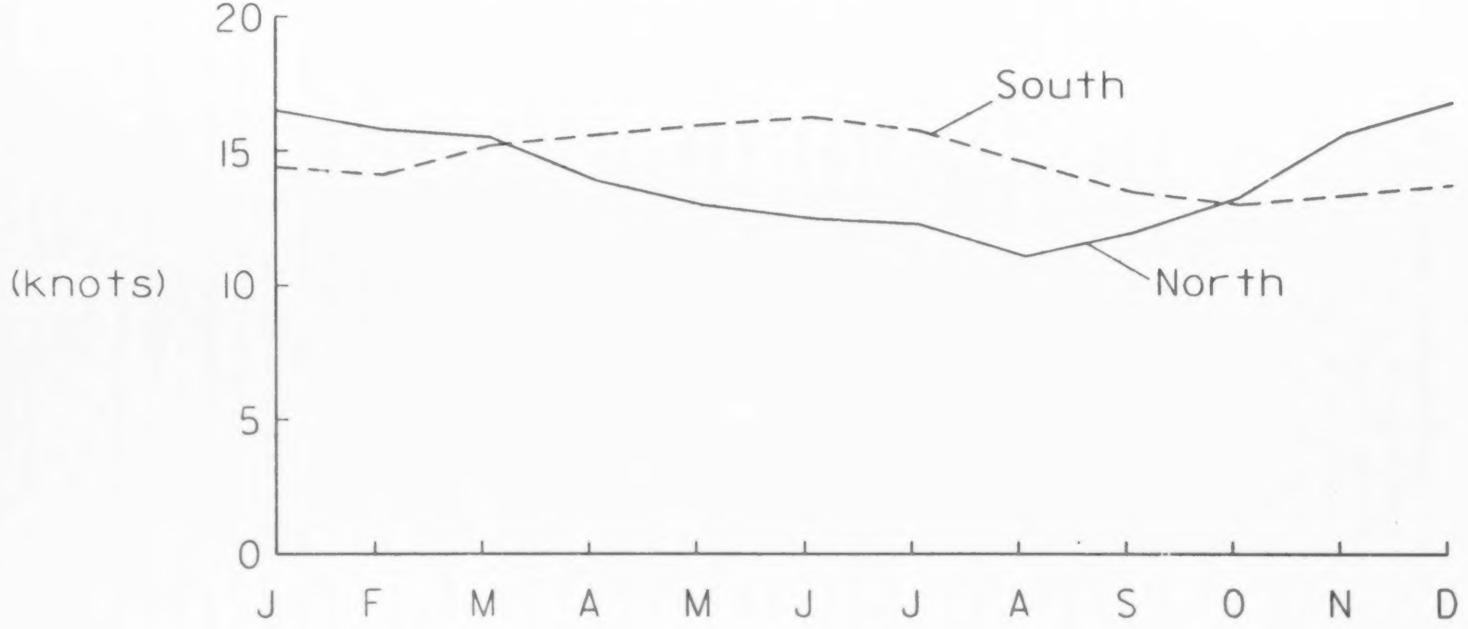
5.3.2.3 Average Wind Speeds

As a general rule for the study area, average wind speed (Figure IV-17) is highest during the winter in northern latitudes and highest during the summer in southern latitudes. Average wind speeds near the coast are generally less than those offshore during any season of the year, although they are consistently greater during the winter months (10-15 knots) than during the summer (9-12 knots). Wind regimes change significantly as the subtropical high migrates southward in the fall. During the period from April through September, winds are typically strongest off of the northern California coast with the highest average wind speeds occurring in an area centered between 45 and 90 nautical miles (nm) offshore of Point Arena and Cape Mendocino. At the center of this area, the average wind speed peaks in July at 19 knots (Figure IV-18). Wind speeds average less during the summer as one moves away from this area; however, they are significantly higher (greater than 16 knots) south of Cape Blanco, Oregon, during the summer months than they are farther to the north. The lowest average wind speeds in the north occur in August, ranging from 7 to 12 knots. The lowest average wind speeds south of Cape Mendocino occur during the month of October, ranging from 8 to 14 knots.

By October, the subtropical high-pressure system that dominates the Pacific during the summer months begins to migrate southward and to decrease in size. The winter wind regime begins to establish, although winds near the coast continue to remain light, averaging 8 to 12 knots. During the month of November, the winter wind regime becomes fully established, and by December, peak average wind speeds occur for the northern portion of the study area, both near the coast and offshore (Figure IV-19). December winds near the coast average 15 to 16 knots north of Cape Mendocino and 9 to 14 knots between Cape Mendocino and Morro Bay. Offshore winds average 14 to 15 knots off of central California and 16-19 knots north of Cape Mendocino. January wind patterns closely resemble those of December with only a slight decrease in average wind speeds.

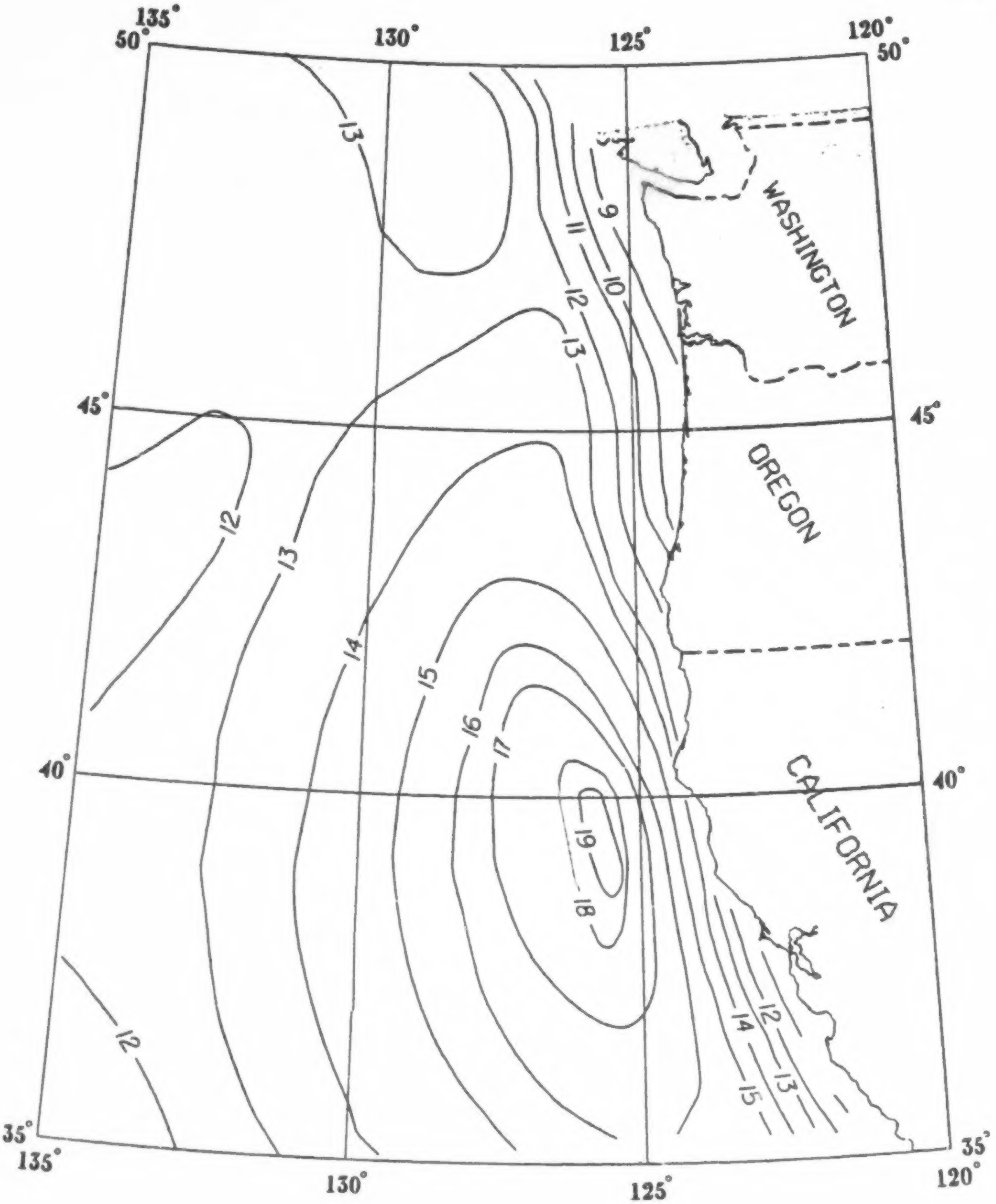
During the months of February and March, the Pacific subtropical high gradually begins to expand northward. Average wind speeds lessen, and by April, the summertime wind regime is fairly well-established again. Wind speeds during the month of April average 11 to 15 knots north of Cape Mendocino and 13 to 15 knots south of there to Morro Bay. Notice that wind speeds in the southern portion of the study area are beginning to exceed those in the northern portion, the reverse of the wintertime pattern. This reversal continues as the subtropical high builds in size and intensity, and an area of relatively high average wind speed begins to reestablish itself off of Cape Mendocino. By May the summertime pattern is fully established and average wind speeds continue to build off of the northern California coast until July when average wind speeds peak for the southern portion of the study area at 19 knots.

The annual average wind speeds for the study area are illustrated in Figure IV-20. As suggested by the July and December average wind speeds (figures IV-18 and IV-19), a marked change in average wind speed occurs in the vicinity of Cape Mendocino. South of Cape Mendocino, winds average less than 15 knots for the year, averaging as low as 10 knots near the coast at San Francisco. From Cape Mendocino northward, winds average greater than 15 knots, increasing to an 18-knot average in the northwestern portion of the study area. The 15-knot wind speed contour has been emphasized in Figure IV-20.



Source: U.S. Department of Commerce, 1988.

Figure IV-17. Average Monthly Wind Speeds.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Contours from U.S. Department of Commerce, 1988

Figure IV-18. Mean July Wind Speeds (knots).

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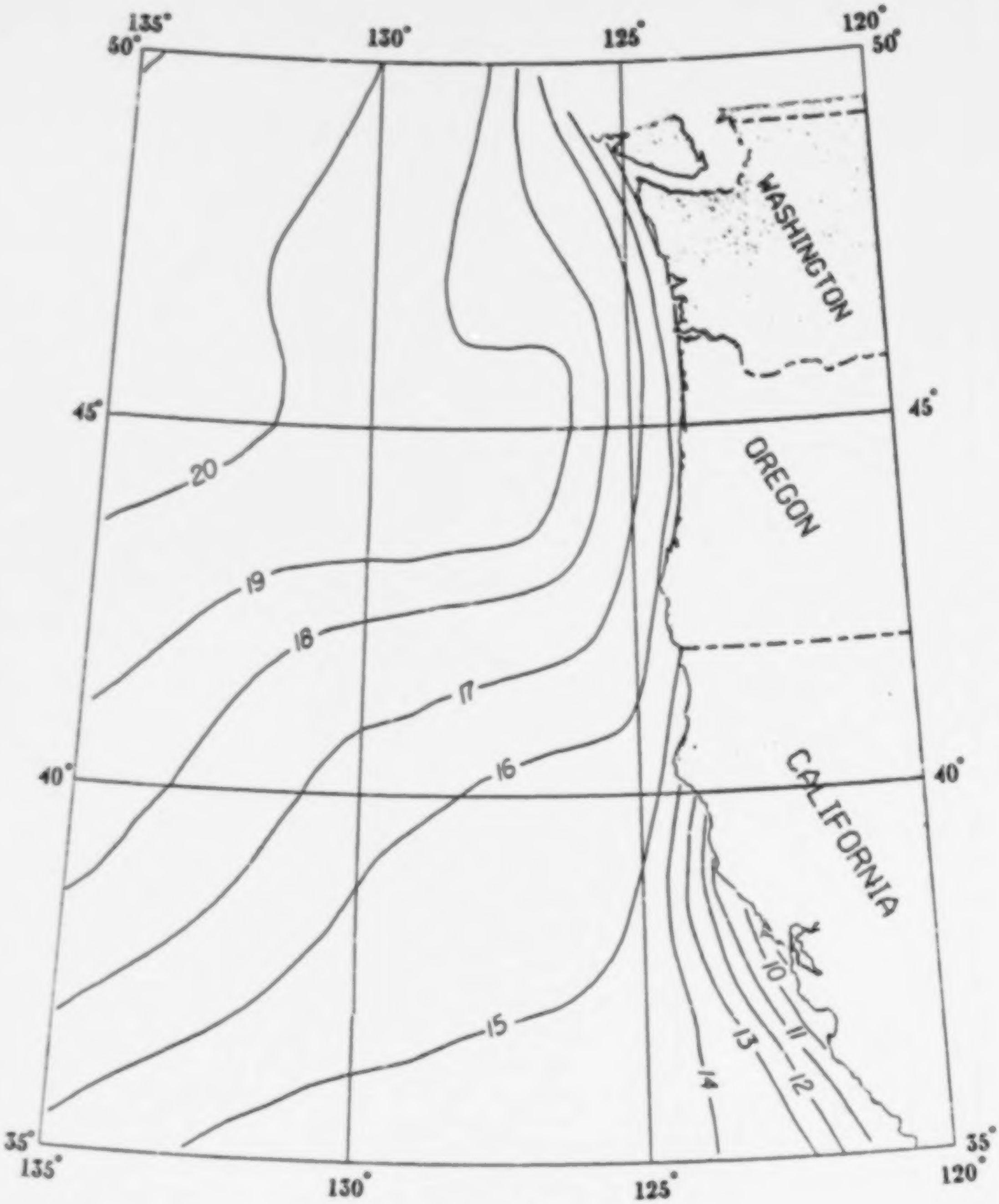
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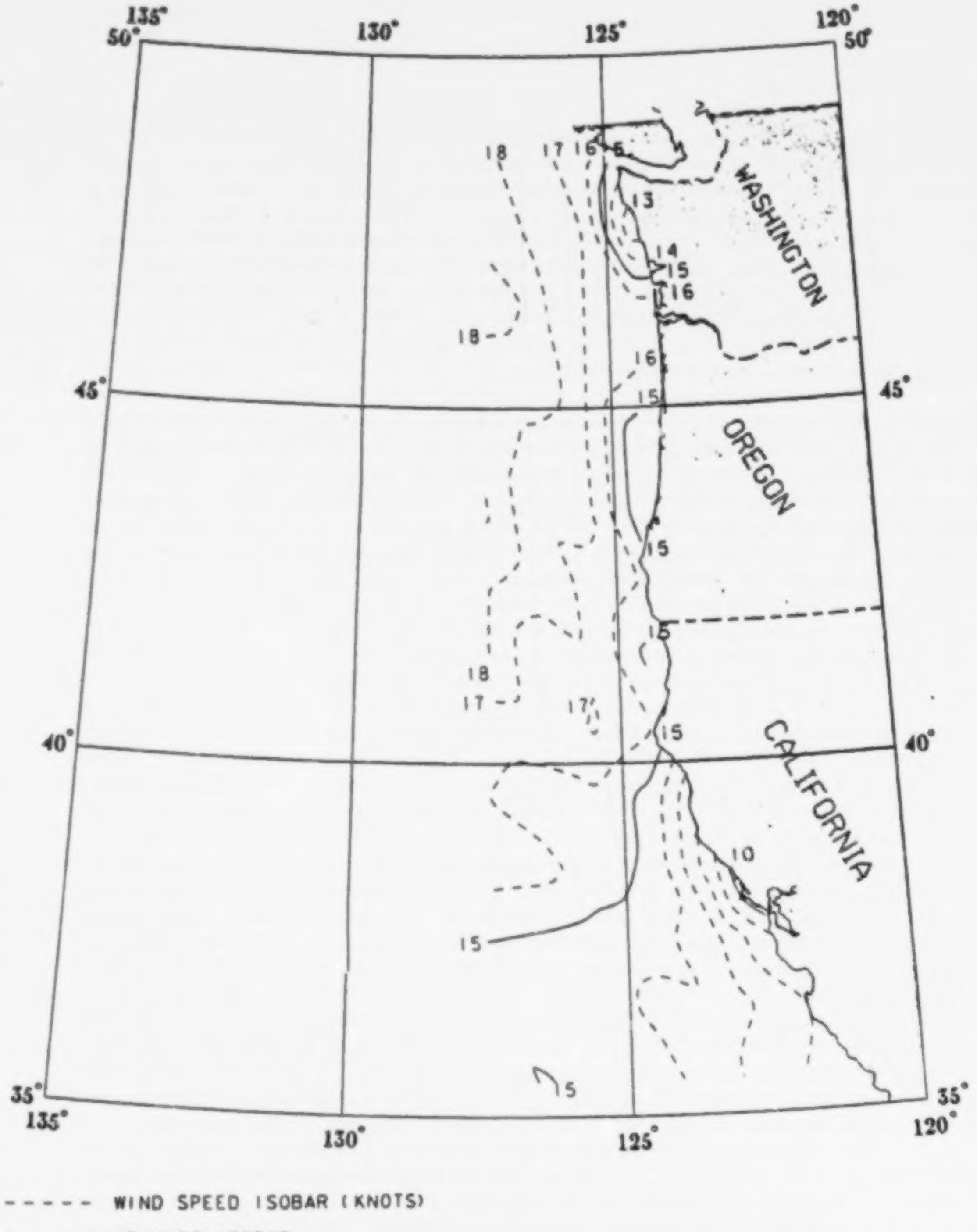
Contours from U.S. Department of Commerce, 1988

Figure IV-19. Mean December Wind Speeds (knots).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- - - - - WIND SPEED ISOBAR (KNOTS)
——— 15-KNOT ISOBAR

Contours from numeric data in U.S. Department of Commerce, 1988

Figure IV-20. Mean Annual Wind Speeds (knots).

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Reproduced from poor document.

5.3.3 Wave Height

Excessive wave height is undoubtedly a serious threat to shipping accounting for approximately 12 percent of vessel losses in the study area. Given large enough waves, ships can be pounded to pieces on what appears to be, under normal circumstances, the most hospitable of beaches. With the exception of tsunamis, wave height is directly related to wind velocity, to duration of sustained wind velocity, and to the unobstructed distance across the water which this wind travels, known as fetch. Except in protected waters, there is no practical limit to fetch in the study area. We can expect a very high positive correlation between wind velocity and wave height on the open ocean; although, wave height lags behind wind velocity in time. When strong winds begin to build, wave height tends to develop rapidly. It generally takes considerably longer for wave heights to decrease once the wind dies off.

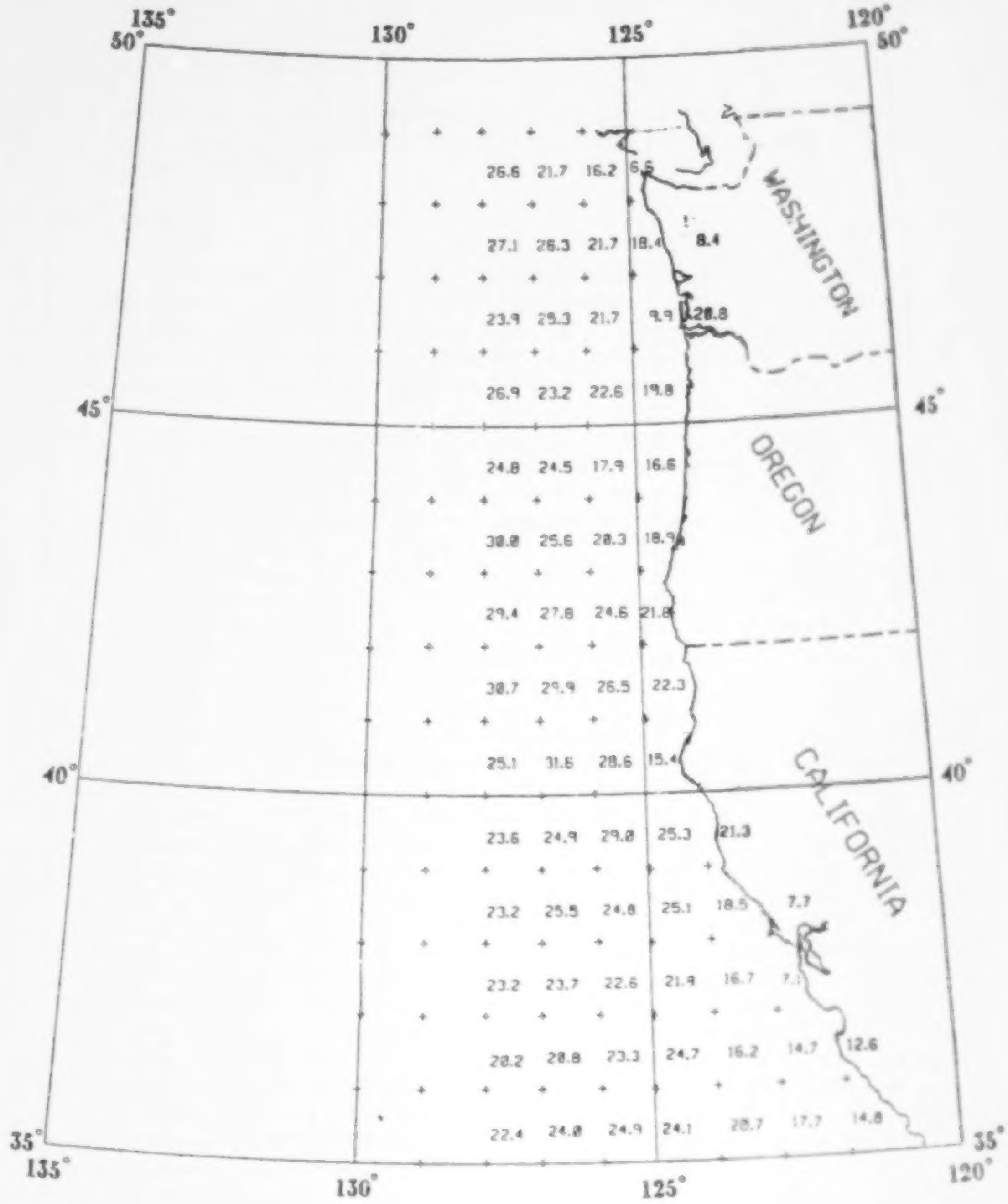
Large waves have a tendency to become even taller and steeper as they approach shallow water or when they encounter opposing currents; however, wave height generally decreases as it approaches the coast of the study area due to decreasing wind velocities and relatively deep waters near the coast. Nevertheless, waves of sufficient size to pose a threat to shipping are relatively common during the windy months of the year. Waves frequently build to exaggerated heights at harbor bars due to the tendency of the strong opposing current to inhibit the forward movement of the wave, combined with the effect of shoal water on wave height. Due to the shortened wavelength, the wave height increases. Water essentially piles up under these circumstances. This is most pronounced in the study area at the mouth of the Columbia River earning the area the title, "Graveyard of the Pacific" (Gibbs 1964). The San Francisco Bar is also noted as an especially hazardous area for shipping. For the purposes of this predictive model, all harbor entrances will be treated as especially high probability areas for vessel loss.

The average frequencies of wave heights greater than 10 ft were calculated separately for the areas north and south of 41 degrees latitude during the summer and during the winter months from the statistics presented in USDC (1988). It should be noted here that shipboard estimates of wave heights are subject to more biases than, and are therefore less precise than, wind velocity observations. Quayle (1980 cited in USDC 1988) states that wave height estimates are generally too low, wave period estimates too short, and sea-swell discrimination poor.

Figure IV-21 illustrates the average annual frequency distribution for waves greater than 10 ft high. As expected, the distribution of heavy seas fairly closely approximates the average wind speed distribution of the study area (Figure IV-20). There are, however, some notable differences. For example, whereas the highest average winds occur in the extreme northwestern portion of the study area, heavy seas occur most frequently in an area centered from 85 to 120 nautical miles offshore of Cape Mendocino. This is likely due to the fact that average wind speeds (Figure IV-17) and wave height frequencies (Figure IV-22) in the south do not change from summer to winter to the extent that they do in the north. The average wind speeds north of 41 degrees for the period May through September are lower than the average wind speeds in the south during any month of the year. In general, the monthly distribution curves for wind speed and wave height frequency are much flatter for the southern area than for the northern area.

The frequency of wave heights greater than 10 ft is significantly higher for the northern area in winter (averaging 32.6 percent) than for the southern area for the same period (averaging 23.3 percent). The highest frequency of waves greater than 10 ft high (38.2 percent) occurs north of 41 degrees latitude during the month of December. The area south of 41 degrees has its highest frequency of heavy seas during the month of March. The winter season for the north, as reflected by wave height frequencies, runs from November through March. In the south, frequent heavy seas begin in November and last through the month of April.

During the summertime (May through September), the northern portion of the study area experiences the lowest percentage of heavy seas of the year for the entire study area. The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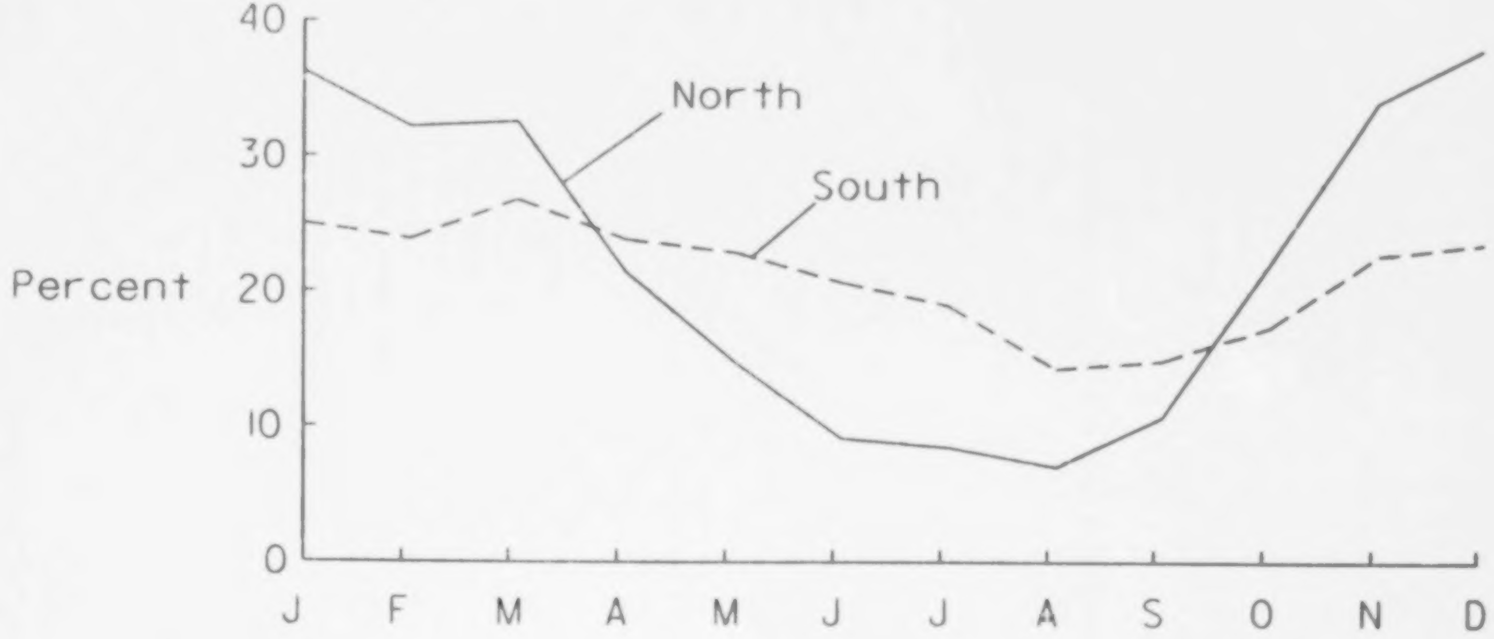
30.0 25.6 20.3 18.9
29.4 27.8 24.6 21.8
30.7 29.9 26.5 22.3
25.1 31.6 28.6 15.4
23.6 24.9 29.0 25.3 21.3
23.2 25.5 24.8 25.1 18.5 7.7
23.2 23.7 22.6 21.9 16.7 7.1
20.2 20.8 23.3 24.7 16.2 14.7 12.6
22.4 24.0 24.9 24.1 20.7 17.7 14.8

Numeric data from U.S. Department of Commerce, 1988

Figure IV-21. Average Annual Distribution (%) of Waves Greater than 10 Feet High.



Source: U.S. Department of Commerce, 1988.

Figure IV-22 Average Monthly Frequencies (%) of Waves Greater than 10 Feet High.

southern area does not attain an average frequency of heavy seas so low as this during any part of the year. The southern portion of the study area experiences its lowest frequencies of heavy seas from June through October.

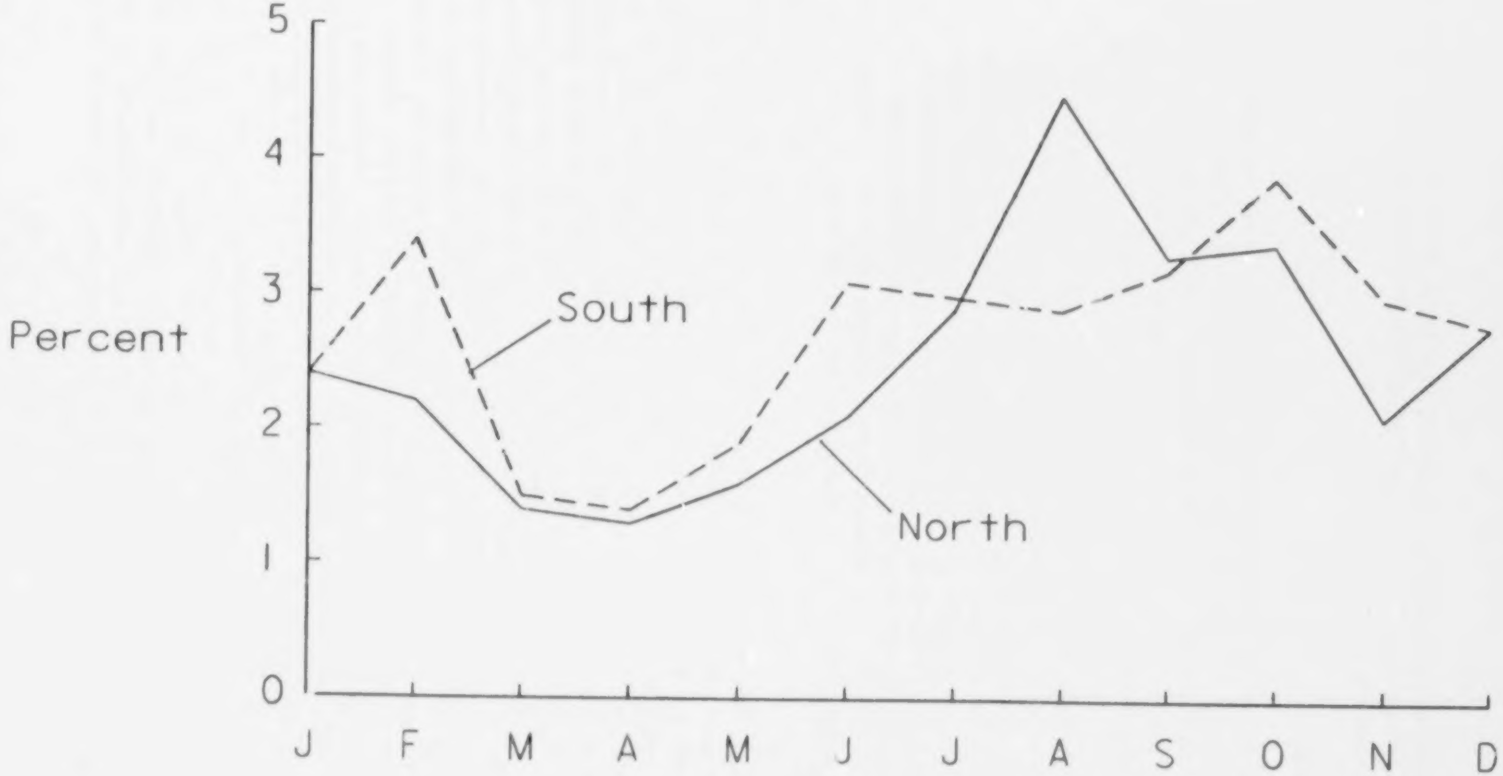
5.3.4 Visibility

Fog is a common cause of marine disasters. In poor visibility, ships run the risk of collision with other ships, or with rocks, reefs, bars and beaches. The *Annual Reports* of the U.S. Life-Saving Service indicate that during the period 1876 to 1914, fog was responsible for 13.1 percent of all vessel losses. Fog occurs at all times of the year in the study area. The Pacific Coast Pilot characterized the distribution of fog along the coast as follows:

> On the outside coast fogs are liable to occur at any time, but are more frequent in July, August, and September. On the southern part of the coast they are light and generally clear away by noon. In the northern parts of the coast they are more frequent and at times are very dense, and have been known to extend several hundred miles seaward. They continue at times for weeks, rendering navigation difficult, and frequently require considerable wind to dispel them. They are generally brought in toward sundown from seaward by light westerly winds, and ordinarily continue until noon of the following day and sometimes later (USDCL 1903).

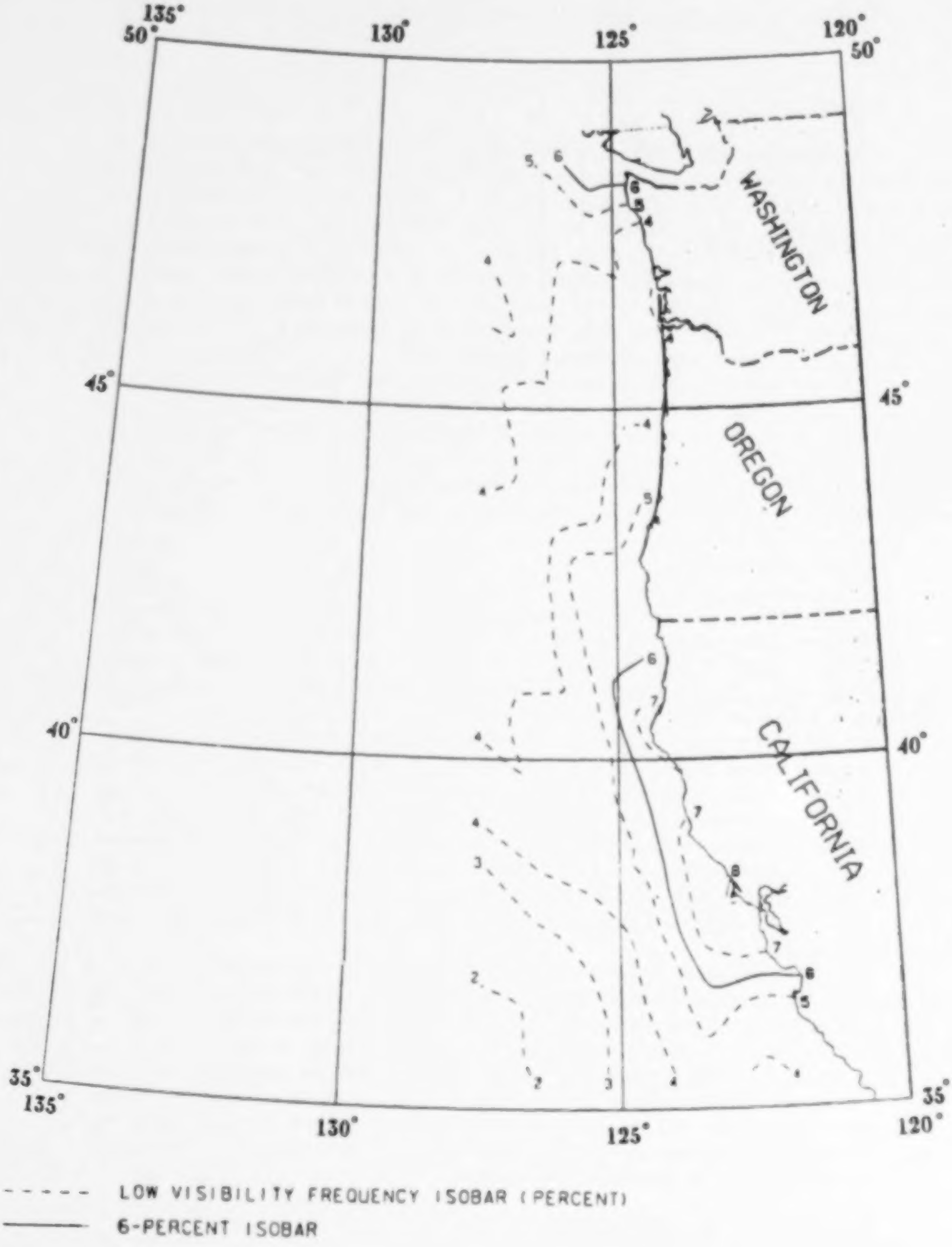
Average frequencies of low visibility (<1 nautical mile) have been calculated separately for the northern and southern portions of the study area from USDC (1988) and are presented graphically in Figure IV-23. There are slight discrepancies between the above quotation from the Pacific Coast Pilot and frequencies calculated from shipboard observations. The foggiest months in the north are July through October with another smaller peak in December. South of 41 degrees, heavy fog (i.e., visibility <1 nautical mile) occurs with a slightly higher frequency than to the north when looking at the year as a whole; however, the incidence of low visibility is not concentrated within such a narrow time frame as in the north. In other words, fog is a little less predictable as to season of occurrence in the south. The months of March through May have the lowest frequencies of poor visibility for the year throughout the study area. Notice the correlation between low average speed (Figure IV-17) and the incidence of low visibility (Figure IV-23).

The average annual frequencies for visibility of less than one nautical mile due to fog are illustrated as contours in Figure IV-24. One can see from this figure that offshore visibility is typically less than one nautical mile for less than 5 percent of the year. Visibility nearer the coast decreases along the central and northern California coasts and near Cape Flattery to frequencies of greater than 6 percent (solid contour). South of Point Arena, California, to just south of San Francisco, the visibility deteriorates to frequencies of greater than 7 percent (nearly one month out of each year). Near the coast of northern Oregon and Washington (below Cape Flattery), visibility approximates conditions offshore with frequencies as low as 4 percent (15 days per year) being common. Along the southern Oregon coast, visibility is slightly poorer although not as frequently low as along the California Coast. It is important to remember when looking at Figure IV-24, that visibilities in protected areas, for example, in bays or downwind from headlands, may have more frequent and longer lasting heavy fogs than would unprotected areas. This factor is not accounted for in Figure IV-24.



Source: U.S. Department of Commerce, 1988.

Figure IV-23. Average Monthly Frequencies (%) of Visibilities Less Than One Nautical Mile Due to Fog.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——— 6-PERCENT ISOBAR

Contours from numeric data in U.S. Department of Commerce, 1988

Figure IV-24. Average Annual Distribution (%) of Visibilities Less than One Nautical Mile Due to Fog.

5.3.5 Surface Currents

The prevailing surface currents for the north Pacific are illustrated in Figure IV-25. The cold California Current flows in a southeasterly direction in the study area during the summer months driven by the subtropical high pressure system that dominates the north Pacific in this season. The Pacific Coast Pilot (USDCL 1903) describes this current as 200 to 300 miles wide with an estimated velocity of about 3/4 knot. Figure IV-25 (USDC 1988) indicates an average velocity of less than half this value. The velocity of this and all currents varies with variation in the trade winds. The net movement of water away from the coast in the surface layer causes upwelling of nutrient-rich deep waters along the coast during spring and summer. The area enriched by this upwelling is a major commercial fishing ground.

During winter, as the subtropical high pressure becomes less dominant in the north Pacific, the path of the Aleutian Current migrates southward causing offshore currents in the northern portion of the study area to flow northward. Offshore currents south of Cape Mendocino continue to flow in a southerly direction. During winter a northerly current, known as the Davidson Inshore Current, becomes established near the mainland along the entire west coast. This current follows the trend of the coast and at times can cause tidal rips nearshore (USDCL 1903).

5.4 Vessel Traffic Patterns

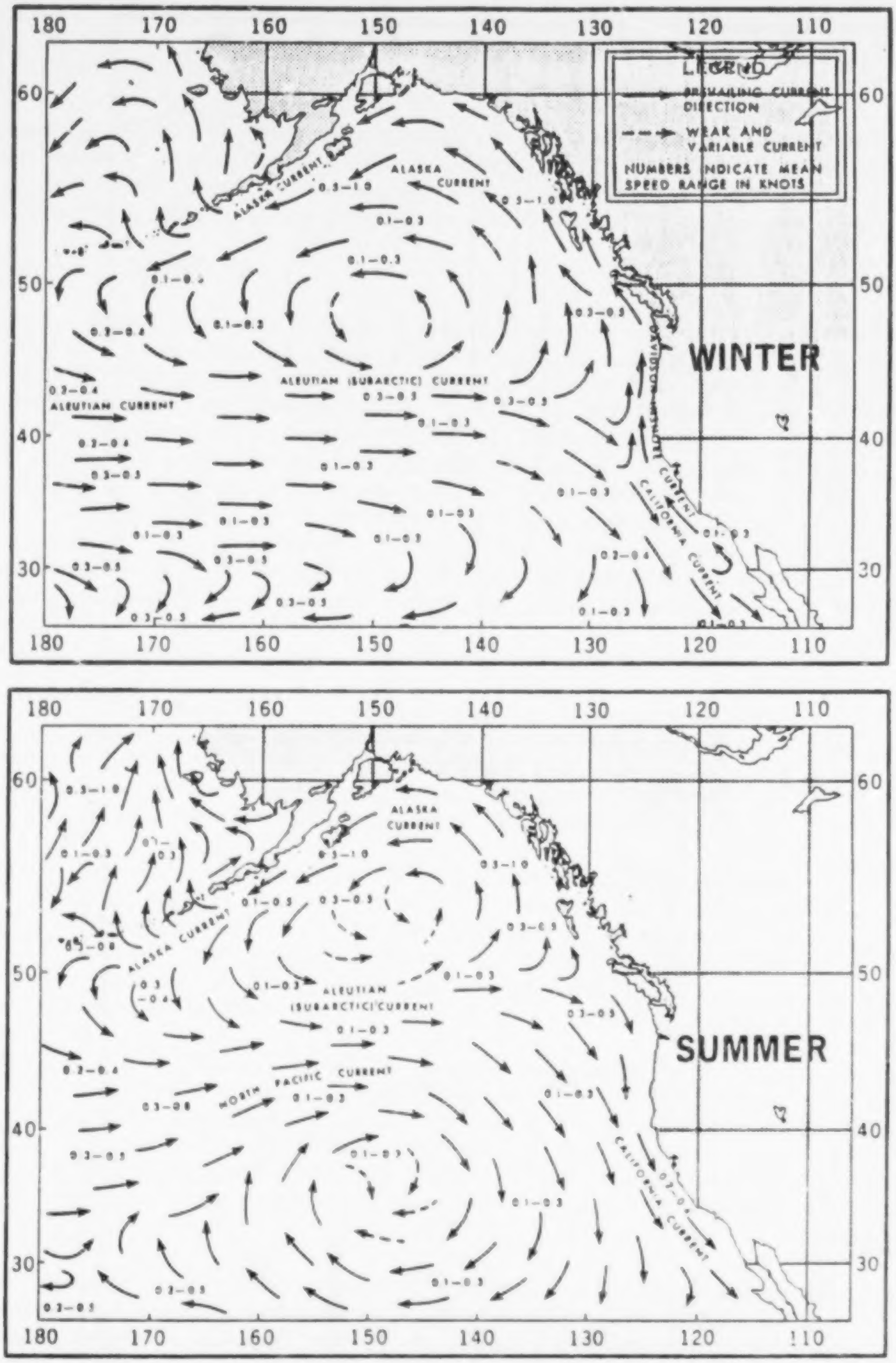
Although the distribution of shipwrecks is influenced by environmental factors, it is even more dependent upon vessel traffic patterns, for one cannot have a shipwreck without first having a ship. The number of shipwrecks having occurred in a given area of ocean is directly proportional to the number of vessels that passed through this same area, taking into consideration (weighted by) the severity of navigational hazards in this same area of ocean.

The interplay between vessel traffic and environmental factors is reflected to a degree by the distribution of known wrecks (Section 5.5); however, if we rely upon the distribution of known wrecks to tell us where unknown wrecks may be located, we would likely have a picture biased in favor of nearshore wrecks. The facts are that wrecks exist in water deeper than 10 m, and the distribution of known wrecks cannot predict their locations with nearly the effectiveness that is possible in the nearshore zone due to the small number of offshore wrecks. Although the percentage of known wrecks occurring offshore is relatively small (approximately 9 percent; see Table IV-4), their small numbers are at least partially offset by their preservation potential (see discussion, Section 5.7).

Accurate locations of offshore wrecks are not commonly reported due to a lack of visible landmarks offshore and to the difficulties of obtaining navigational fixes while a ship is going down. The latter is due not only to the urgency of marine disasters but also because the majority of sinkings occur in severe weather when celestial navigation is impossible. If a position is known for an offshore wreck, it is likely based on the last position charted by the captain of the vessel. This could be a significant distance from the actual place of sinking, due to storm winds. In the case of vessels lost at sea, where the captain and crew did not survive, it can only be assumed that the vessel was lost somewhere near the sealanes between its point of departure and its planned destination (unless sighted by another vessel after sailing).

5.4.1 Sealanes During the "Age of Sail"

Sealanes are areas located enroute between major ports, having a relatively high density of vessel traffic. Sealanes are generally depicted on charts as a fine arc connecting two points, as in an 1857 chart (Figure IV-26) produced by the U.S. North Pacific Surveying Expedition (Rodgers 1857). Although Rodgers' chart was not intended as a navigation chart, Figure IV-26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LEGEND
PREVAILING CURRENT DIRECTION
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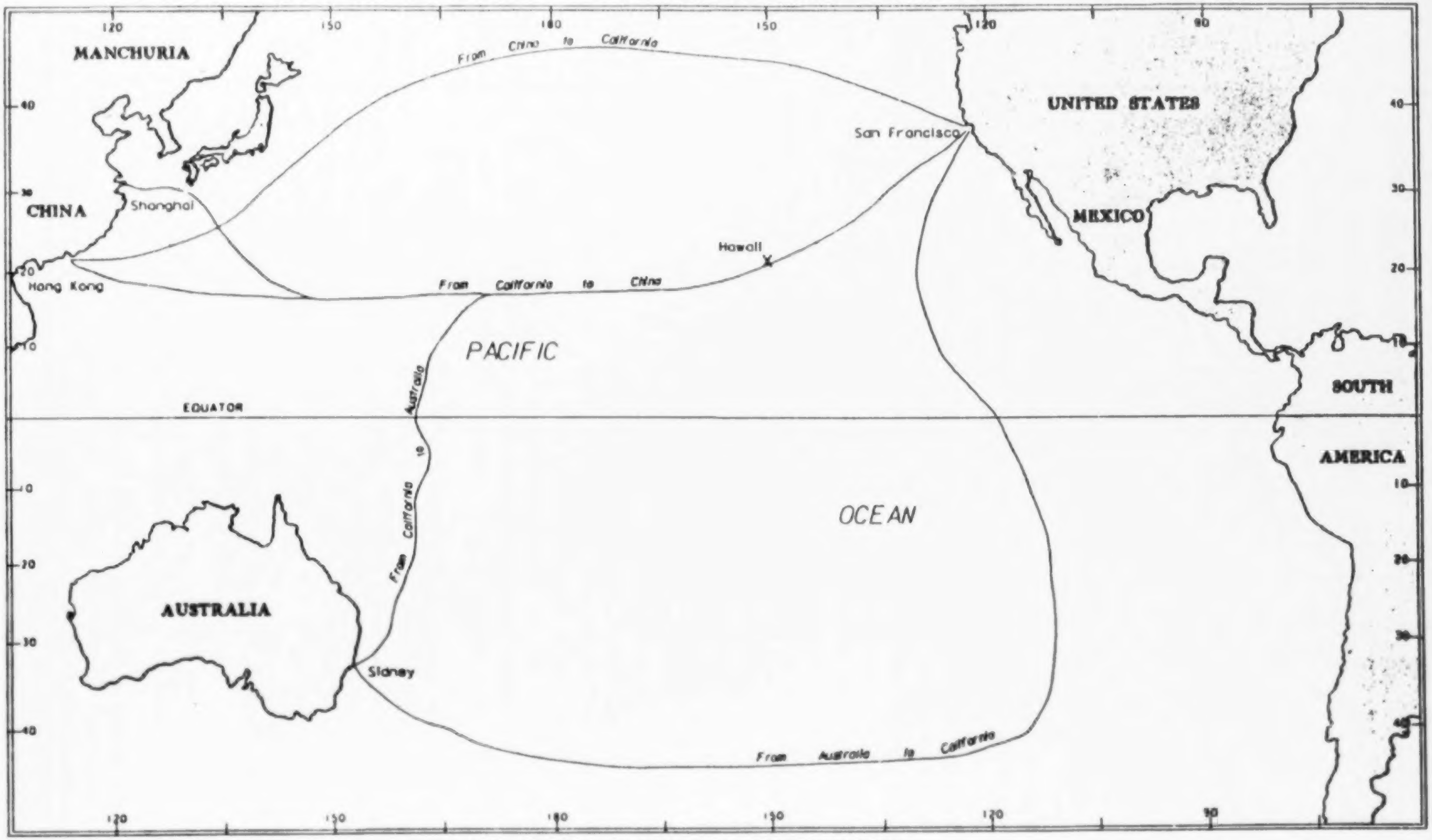
NUMBERS INDICATE MEAN SPEED RANGE IN KNOTS
ALASKA CURRENT
ALEUTIAN (SUBARCTIC) CURRENT
ALEUTIAN CURRENT
DAVIDSON INSHORE CURRENT
CALIFORNIA CURRENT
WINTER
NORTH PACIFIC CURRENT
SUMMER

Source: U.S. Department of Commerce, 1988

Figure IV-25. Surface Currents (summer and winter).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AUSTRALIA
San Francisco
Hawaii
Sidney
PACIFIC
OCEAN
EQUATOR
From China to California
From California to China
From California to Australia
From Australia to California
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30
20
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0
10
20
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40

Source: (Rogers, 1857) Register Chart of Reported Dangers in the Pacific Ocean, Courtesy of Library of Congress

Figure IV-26. Generalized Chart of Mid-Nineteenth Century Pacific Sailing Routes.

illustrates generalized transpacific sailing routes. The routes shown are the courses that were ideally followed to get from Point A to Point B in the shortest amount of time. In the real world, sailing vessels seldom, if ever, followed routes as precise as these. During the age of sail, sealanes were often 150 to 250 miles wide because of the vagaries of prevailing winds and currents.

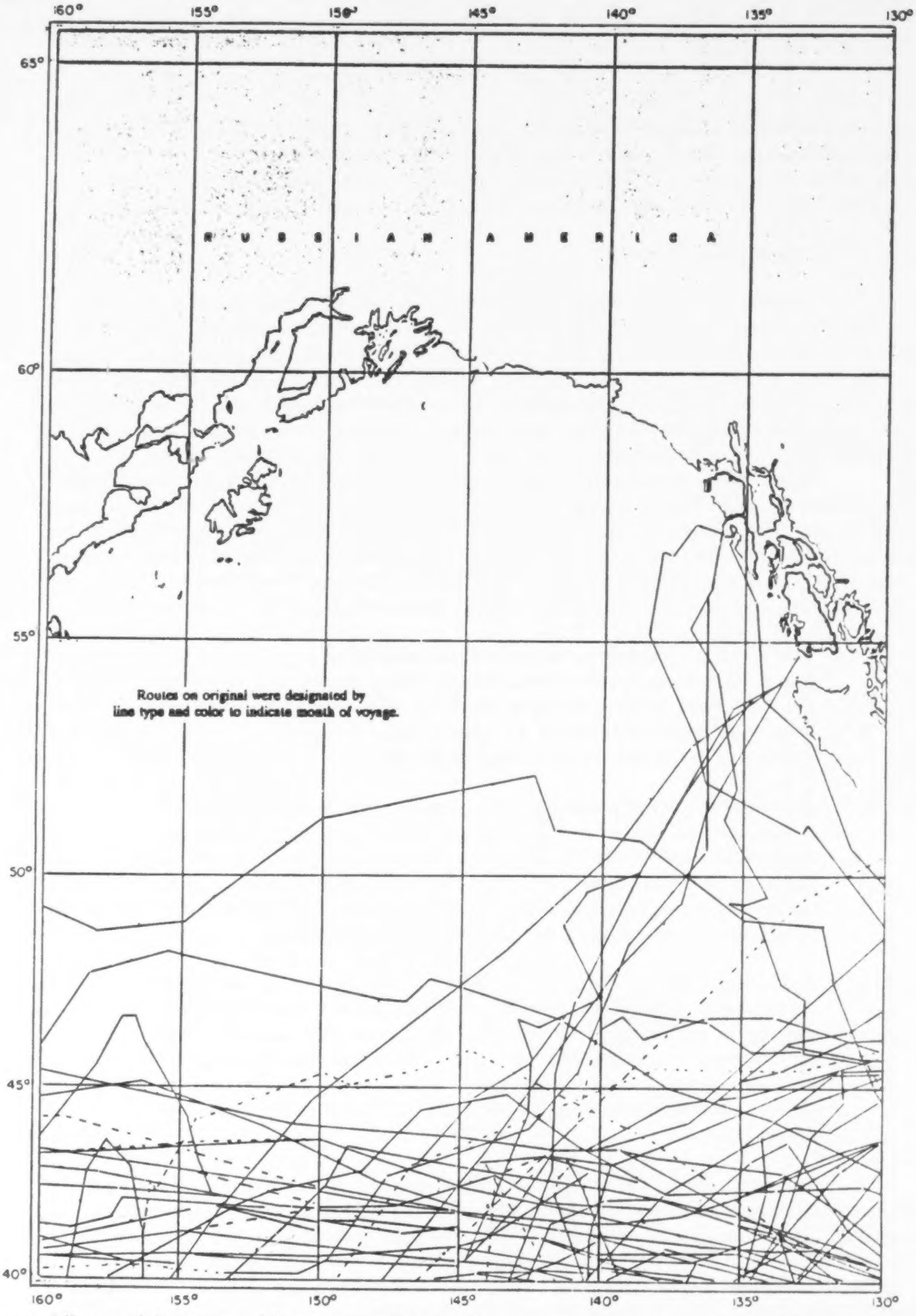
5.4.1.1 Maury Track Charts

A much more precise picture of sealanes followed by sailing vessels is illustrated in Figure IV-27, a series of four adjoining charts covering the North Pacific Ocean from the study area out to the Hawaiian Islands. The charts shown in Figure IV-27 were produced by Matthew Fontaine Maury and published by the U.S. Navy Hydrographic Office in 1852 under the title "Wind and Current Charts". Maury produced wind and current charts for the Atlantic, Pacific and Indian oceans as part of a larger set of charts summarizing climatic and oceanographic data as aids to marine navigation. The Wind and Current Charts were published as Series A of this set.

Other charts of the world's major oceans produced by Maury include: Trade Wind Charts (Series B); Pilot Charts (Series C); Thermal Charts (Series D); Storm and Rain Charts (Series E), and Whale Charts (Series F). His Wind and Current Charts are the most useful to this study, as they show the tracks of individual sailing vessels, plotted from positions recorded in ships' logbooks. For this reason they have come to be popularly known as "Track Charts". The purpose behind the Wind and Current (Track) Charts is best summarized in Maury's own words.

> The primary object of the Wind and Current Charts, out of which has grown the Treatise on the Physical Geography of the Sea, was to collect the experience of every navigator as to the winds and currents of the ocean, to discuss his observations upon them, and then to present the world with the results on charts for the improvement of navigation.
>
> Accordingly, when this object was made known, an appeal was addressed to the mariners, there was a flight up into the garrets, and a ransacking of time-honored sea-chests in all the maritime communities of the country for old log-books and journals. It was supposed that the records therein contained as to the wind and weather, the sea and its currents, would afford information requisite for such an undertaking.
>
> By putting down on a chart the tracks of many vessels on the same voyage but at different times, in different years, and during all seasons, and by projecting along each track the winds and currents daily encountered, it was plain that the navigator hereafter, by consulting this chart, would have for a guide the results of the combined experience of all those whose tracks were thus pointed out (Maury 1855 quoted in Pinsel 1981).

Examining the Track Charts illustrated in Figure IV-27, it is immediately apparent that sailing vessels followed very broad sealanes. Maury's Track Charts bear little resemblance to the generalized sealanes indicated in Figure IV-26. Seasonal variations in prevailing winds and currents (refer back to Section 5.3; figures IV-14 and IV-25) affected the paths of sailing vessels so that vessels seldom followed the same route twice. It is uncertain as to the proportion of voyages represented in Maury's charts; nevertheless, they provide an excellent picture of where the majority of ocean-going vessel traffic was concentrated during the early- to mid-nineteenth century.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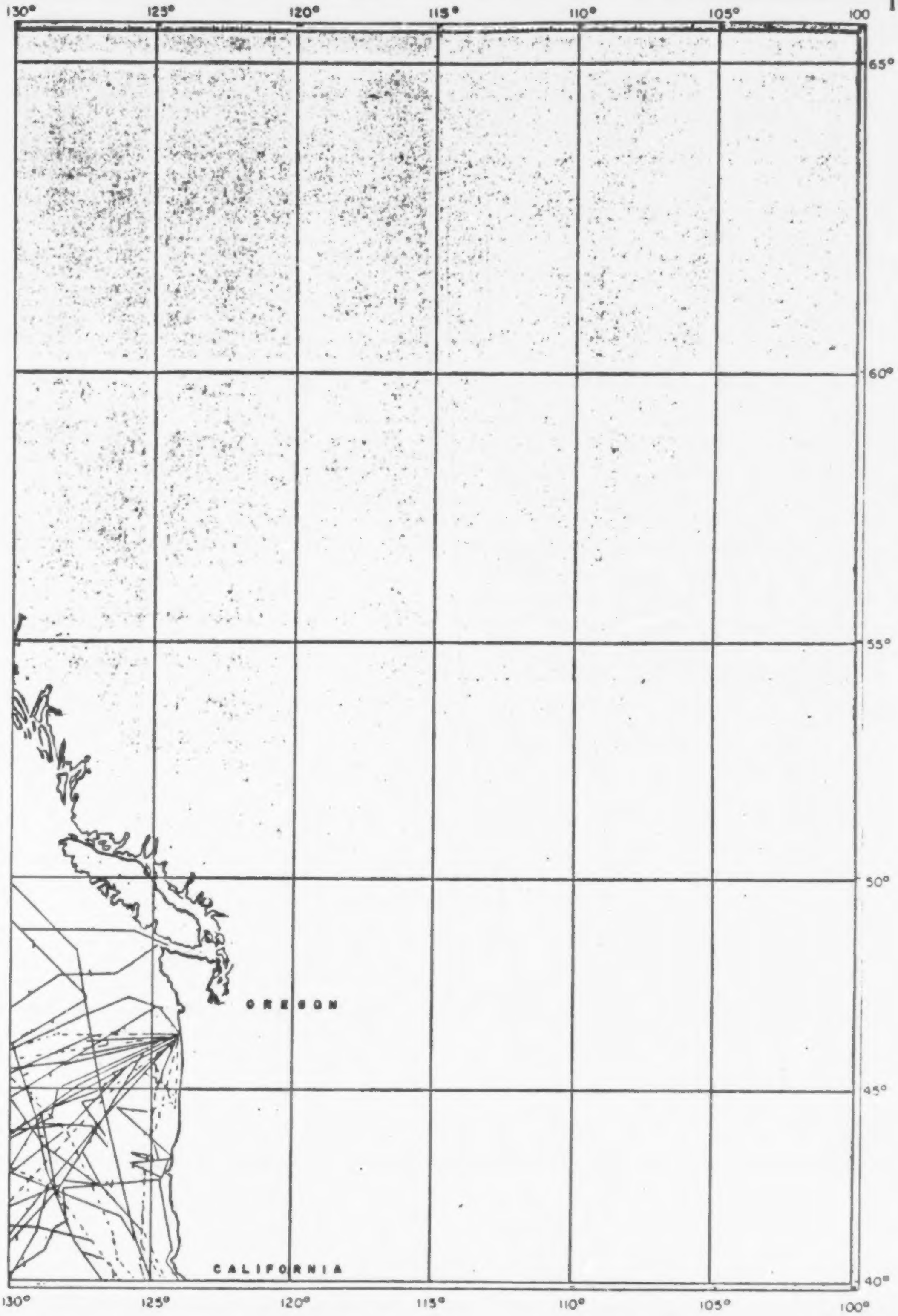
RUSSIAN AMERICA

Routes on original were designated by line type and color to indicate month of voyage.

Source: Library of Congress. After Maury's Wind & Current Chart, North Pacific, Series A, #4.

Figure IV-27a. Maury Track Charts of the Northeast Pacific Ocean.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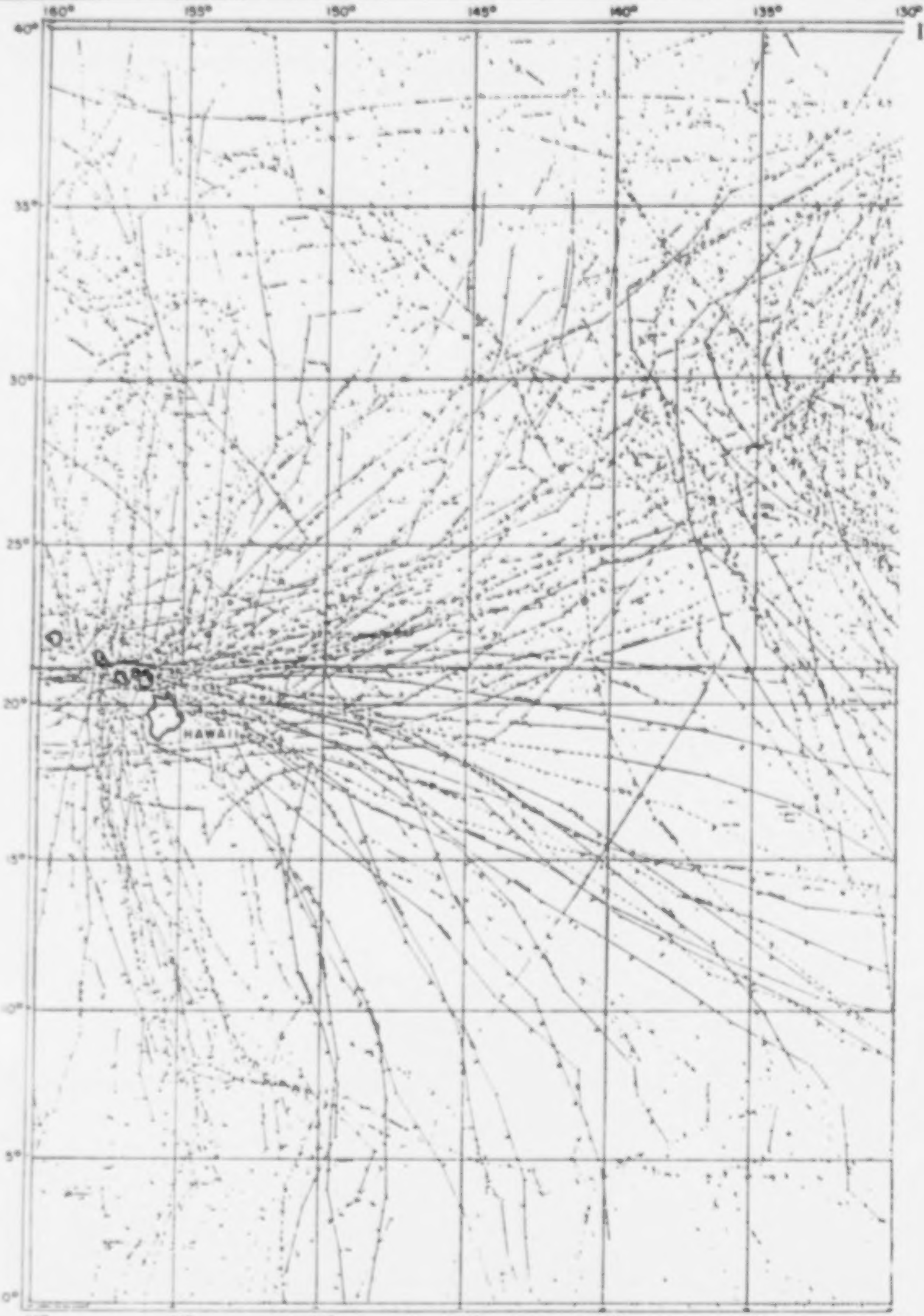
Source: Library of Congress. After Maury's Wind & Current Chart, North Pacific, Series A, #5.

Figure IV-27b. Maury Track Charts of the Northeast Pacific Ocean.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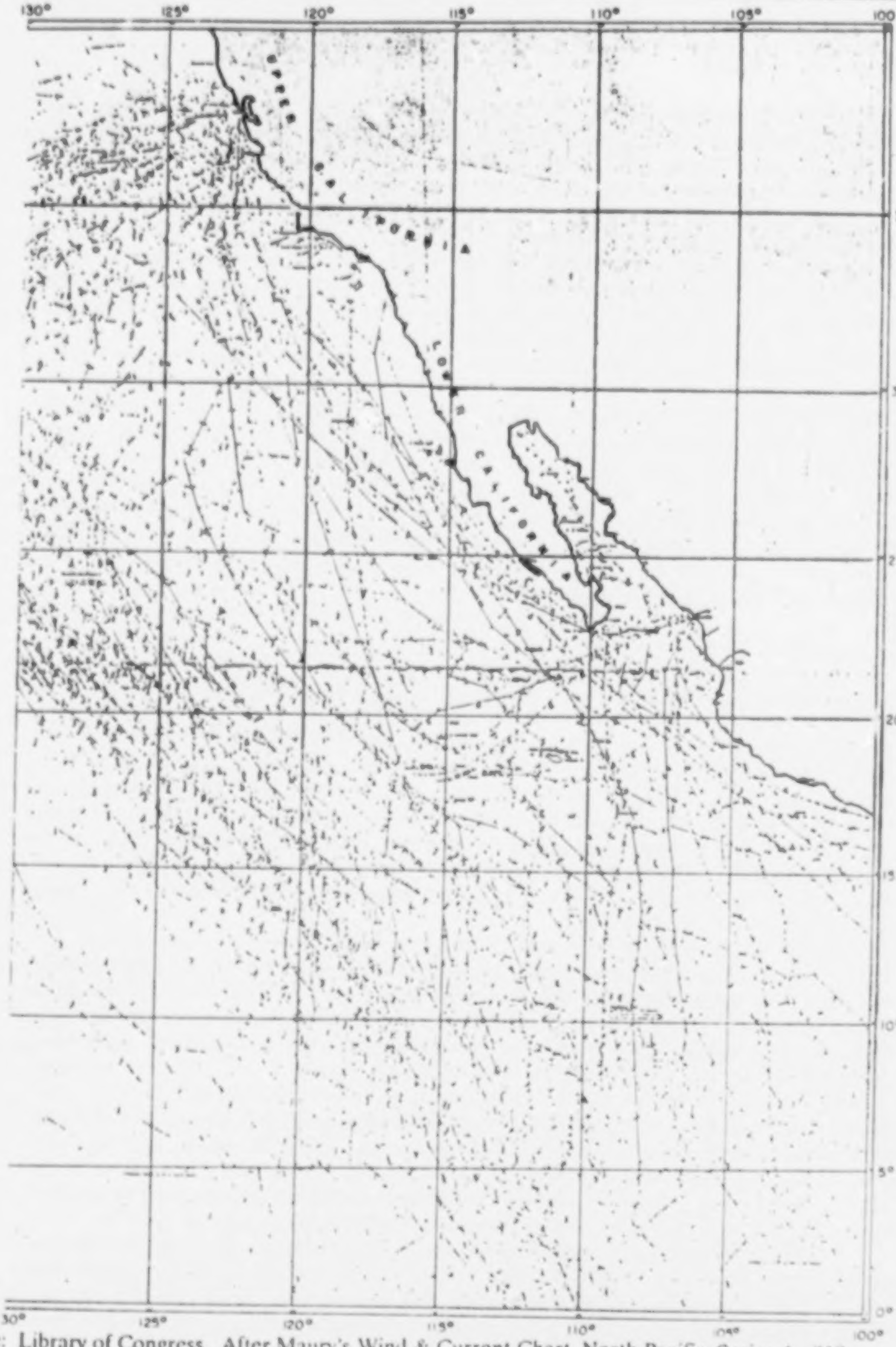
HAWAII

Source: Library of Congress. After Maury's Wind & Current Chart, North Pacific, Series A, #9.

Figure IV-27c. Maury Track Charts of the Northeast Pacific Ocean.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UPPER CALIFORNIA
LOWER CALIFORNIA

Source: Library of Congress. After Maury's Wind & Current Chart, North Pacific, Series A, #10.

Figure IV-27d. Maury Track Charts of the Northeast Pacific Ocean.

The greatest bulk of sail traffic was very obviously centered on San Francisco. The Strait of Juan de Fuca was the only other major trans-Pacific hub at this early date and, although not insignificant, the number of vessels sailing past Cape Flattery prior to 1852 was proportionally much less than the number of vessels sailing through the Golden Gate.

The majority of vessel tracks shown in Figure IV-27 are, no doubt, associated with the period of the Gold Rush. San Francisco had a population of only 400 people in 1846 prior to the Gold Rush. By 1860, its population was 57,000. As a result of the Gold Rush, there was a great demand for lumber in San Francisco. Much of this lumber was carried by coastal schooners, thus it is likely that the amount of coastal traffic was greater for the first half of the nineteenth century than would seem to be indicated by Figure IV-27.

Much of the traffic past Cape Flattery was likely carrying lumber from the Pacific Northwest to Honolulu. The lumber trade with Hawaii began in the 1840s partly as a result of the great demand for ships' timbers in Hawaii. By 1852 one can see (Figure IV-27) what a hub Hawaii had become. Lumber was a valuable commodity there due to the large number of sailing vessels stopping over in Hawaii for repairs. Since all lumber had to be imported to Hawaii, it was common for vessels to be repaired there using timbers of Douglas fir from the Pacific Northwest.

Outside of the dense traffic areas seen in Maury's Track Charts, the seas were not untraveled voids. Much vessel traffic in these areas could likely be accounted for by whaling voyages. Maury's whale chart of the Pacific Ocean (Figure IV-2) shows abundant whale fisheries in nearly every direction from the study area.

5.4.2 *Steam Navigation*

The Pacific coast had its first steam engines by at least 1846 when a steam-powered sawmill was established at Bodega Bay. Steam navigation along the U.S. Pacific coast followed soon after this. According to E. Mowbray Tate (1986), the first steam-powered vessel to arrive on the Pacific coast was the steamer *California* from New York in 1849. By 1850, there were steamships traveling up the Columbia and Williamette rivers as far as Portland, and in 1851 the steamer *Columbia* was engaged in regular coastal service between San Francisco and Portland. The *Columbia* made a run between these two cities with mail, passengers and freight every two to three weeks until 1862. Coastal steamers did not visit Puget Sound on a regular basis until the 1880s, and even then there were only four coasting steamers connecting with the cities of Portland and San Francisco in 1884 (Tate 1986).

Transpacific steam trade began in 1853 when the gold rush in Australia lured miners from California in the steamers *Monumental City* and *New Orleans*. According to Tate (1986), most of the early transpacific steamer crossings were actually under power of sail. In fact, most steamers carried a full complement of masts and sails until the end of the nineteenth century, hence the name steamship. In 1862 the voyages of two steamers, *Cortes* and *Columbia* marked the beginning of reliance upon steam power for transpacific crossings. It was not until 1867, however, that a regular transpacific steam route was established between San Francisco and Hong Kong via Yokohama by the Pacific Mail Steamship Company (Tate 1986). By 1869, Pacific Mail had four new sidewheelers running between San Francisco and Japan-China with at least one departure monthly through 1874. In 1875, Pacific Mail added New Zealand and New South Wales to its transpacific steam routes. San Francisco and the Pacific Mail Steamship Company continued to dominate the transpacific steamship trade throughout the era of steam.

The first transpacific steamer between Yokohama, Japan, and Victoria, British Columbia, arrived at Victoria in 1881 via what was known as the Great Circle Track. Victoria boasted the shortest distance to Yokohama of any Pacific coast city. It was not until the last decade of the nineteenth century that regular transpacific steam routes were established from both the Columbia River and the Strait of Juan de Fuca. During the early 1890s, the Northern Pacific Steamship Company was organized for trade between Tacoma and the Far East. In 1891 the Portland and Oriental Line (also known as Upton's China Line) was established with a run from Portland to Hong Kong via Victoria. This company was short-lived, folding in 1892. In 1895, the Oregon Railroad and Navigation Company announced a direct line to the Orient leaving monthly from Portland. By 1904, steamers were making direct departures from Portland to Hong Kong on a 3-week schedule. Figure IV-28 illustrates the majority of commercial steam routes that had developed from these beginnings by 1940. Figure IV-29 illustrates a composite of steamer routes from several sources for the study area. The routes shown in Figure IV-29 are the basis for the offshore historic site predictive zones illustrated in Volume V.

5.4.3 Coastal Navigation

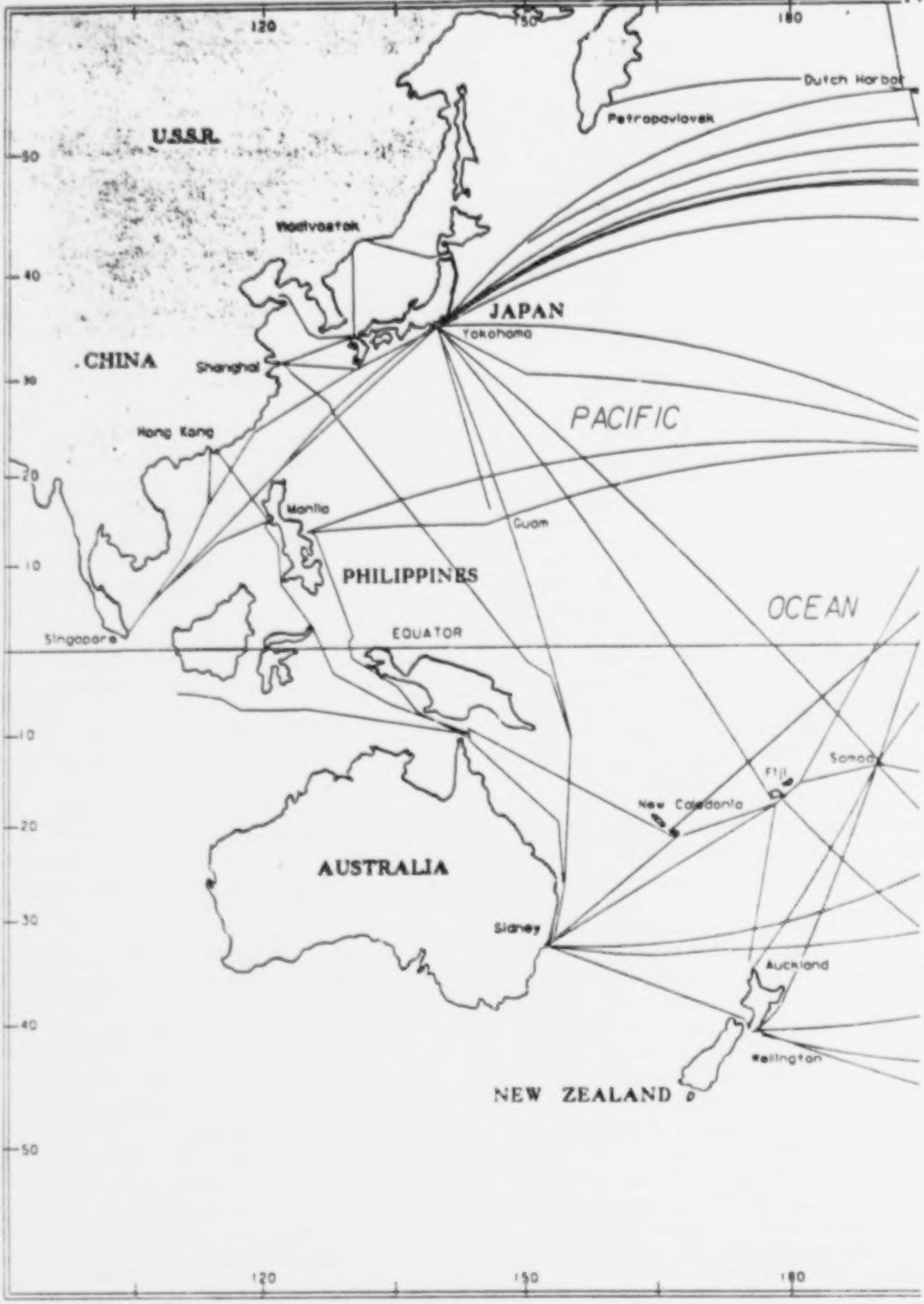
Navigation in coastal waters of the study area did not occur with regularity until the trade in sea otter pelts became a major venture in the mid- to late-eighteenth century. Fur traders frequenting the coast usually sailed across the Pacific with their loads of furs to trade with the Chinese. Early in the nineteenth century, as the sea otter trade was declining, ships began to enter the Pacific Northwest for the purpose of exporting lumber. In 1827, the Hudson's Bay Company opened one of the first sawmills on the Columbia River near Fort Vancouver. The first commercial sawmill in California was opened in 1835 at Sonoma City. By the 1840s, lumber was the number one export product to Hawaii from the Pacific coast.

With the growth of population centers such as San Francisco and Portland during the 1840s, the frequency of domestic traffic along the coast increased greatly. Much of the impetus for this growth was the California Gold Rush and the need to keep the mining towns of California well-supplied with essentials such as lumber.

In 1858 George Davidson of the U.S. Coast Survey (later Coast and Geodetic Survey) completed the first geographic/ hydrographic directory of the U.S. Pacific coast (USCGS 1858). The purpose of this volume was "to state all that is known at the present time of the hydrography and geography of the Pacific coast of the United States from the southern boundary...to the northern boundary" (USCGS 1858:2). In it can be found "descriptions of ports, bays, anchorages, reefs, capes, islands, etc." This was a precursor to the Pacific Coast Pilot Series published by the Coast and Geodetic Survey during the latter half of the nineteenth century and into the twentieth century.

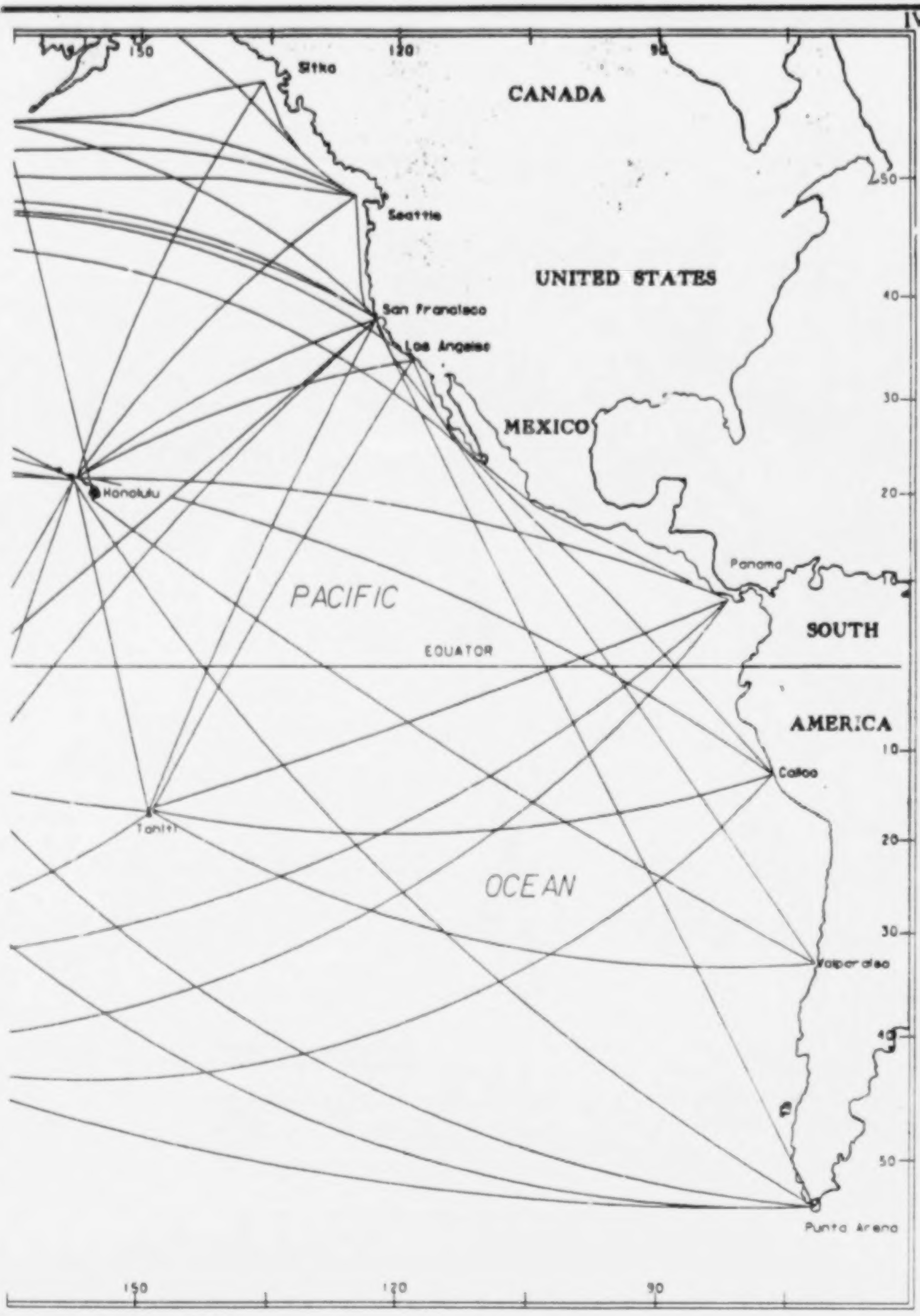
The coastal sailing directions shown in Figure IV-29 are those described in the Pacific Coast Pilot for the year 1903 (USDCL 1903). This volume goes into great detail regarding such matters as safe sailing depths and minimum distances that must be maintained from various points of land in order to assure clearance around rock reefs. A lengthy excerpt has been borrowed from the Pacific Coast Pilot below in order to emphasize the advantages and dangers of sailing the coastal routes.

> **GENERAL REMARKS ON APPROACHING AND SAILING ALONG THE COAST**
>
> In clear weather little difficulty will be experienced in approaching or sailing along the coast. The landmarks for the principal ports are prominent, visible seaward in daytime for a considerable distance, and at night the numerous aids to navigation afford a ready means of locating a vessel's position. The principal ports for which foreign vessels are usually destined are San Diego, San Pedro, San Francisco, Humboldt Bay, the Columbia River, Willapa Bay, Grays Harbor, and Juan de Fuca Strait. For each of these the landmarks are distinctive and easily


120
150
180
U.S.S.R.
Dutch Harbor
Petropavlovsk
50
Vladivostok
40
JAPAN
Yokohama
CHINA
Shanghai
30
PACIFIC
Hong Kong
20
Manila
Guam
10
PHILIPPINES
OCEAN
Singapore
EQUATOR
10
Samoa
Fiji
New Caledonia
20
AUSTRALIA
30
Sidney
Auckland
40
Wellington
NEW ZEALAND
50
120
150
180

Source: U.S. Navy, 1940.

Figure IV-28a. Shipping Lanes in the Pacific Ocean.


150
120
90
Sitka
CANADA
Seattle
UNITED STATES
San Francisco
Los Angeles
MEXICO
Honolulu
Panama
PACIFIC
SOUTH
EQUATOR
AMERICA
Callao
Tahiti
OCEAN
Valparaiso
Punta Arena
50
40
30
20
10
10
20
30
40
50
150
120
90

Source: U.S. Navy, 1940.

Figure IV-28b. Shipping Lanes in the Pacific Ocean.

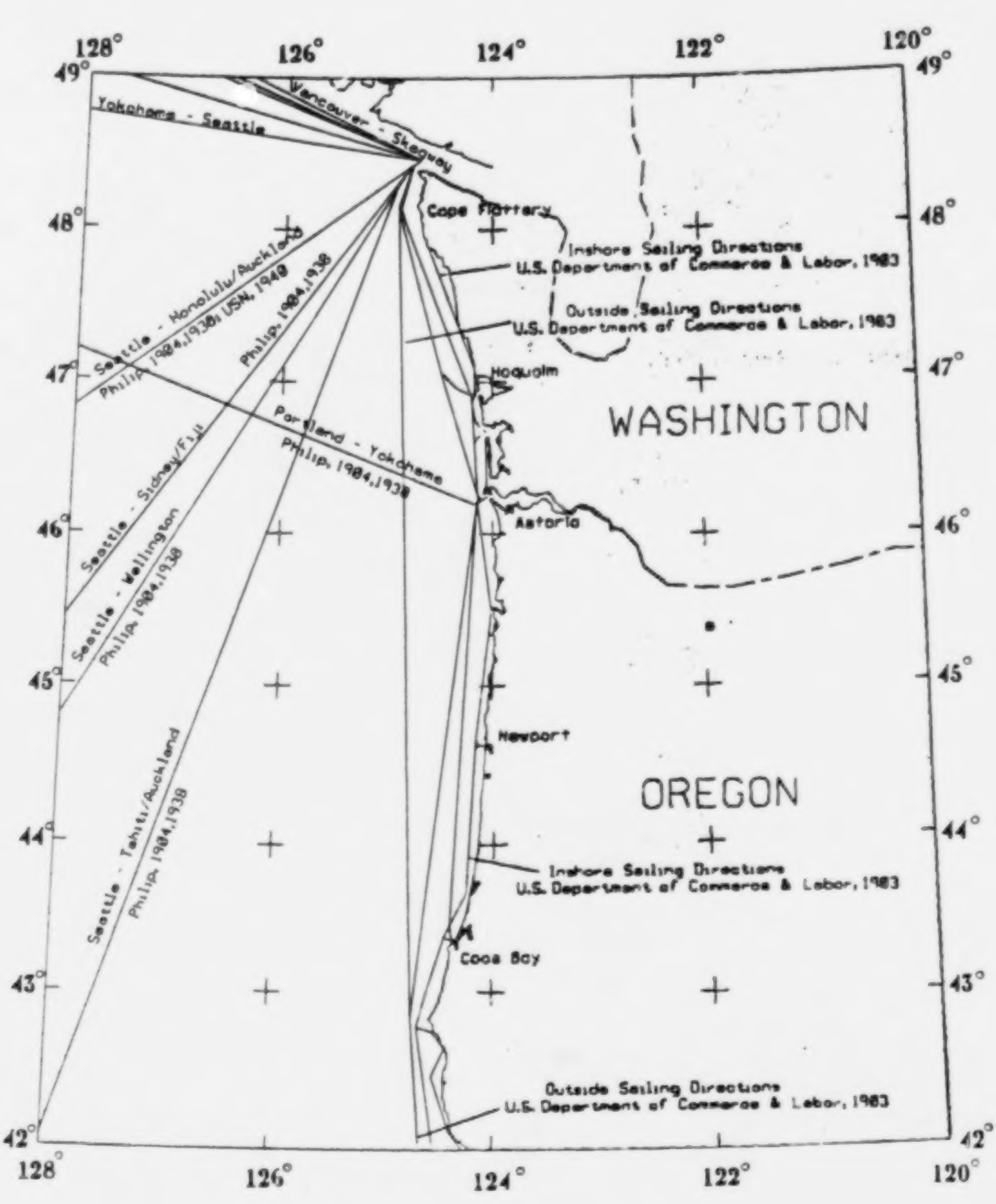

128°
126°
124°
122°
120°
49°
48°
47°
46°
45°
44°
43°
42°
Yokohama - Seattle
Vancouver - Skagway
Cape Flattery
Inshore Sailing Directions
U.S. Department of Commerce & Labor, 1983
Outside Sailing Directions
U.S. Department of Commerce & Labor, 1983
Seattle - Honolulu/Auckland
Philip, 1984,1938; USN, 1949
Philip, 1984,1938
Hoquiam
WASHINGTON
Portland - Yokohama
Philip, 1984,1938
Seattle - Sidney/Fiji
Seattle - Wellington
Philip, 1984,1938
Astoria
Newport
OREGON
Seattle - Tahiti/Auckland
Philip, 1984,1938
Inshore Sailing Directions
U.S. Department of Commerce & Labor, 1983
Coos Bay
Outside Sailing Directions
U.S. Department of Commerce & Labor, 1983

Figure IV-29a. Major Sealanes in the Study Area.

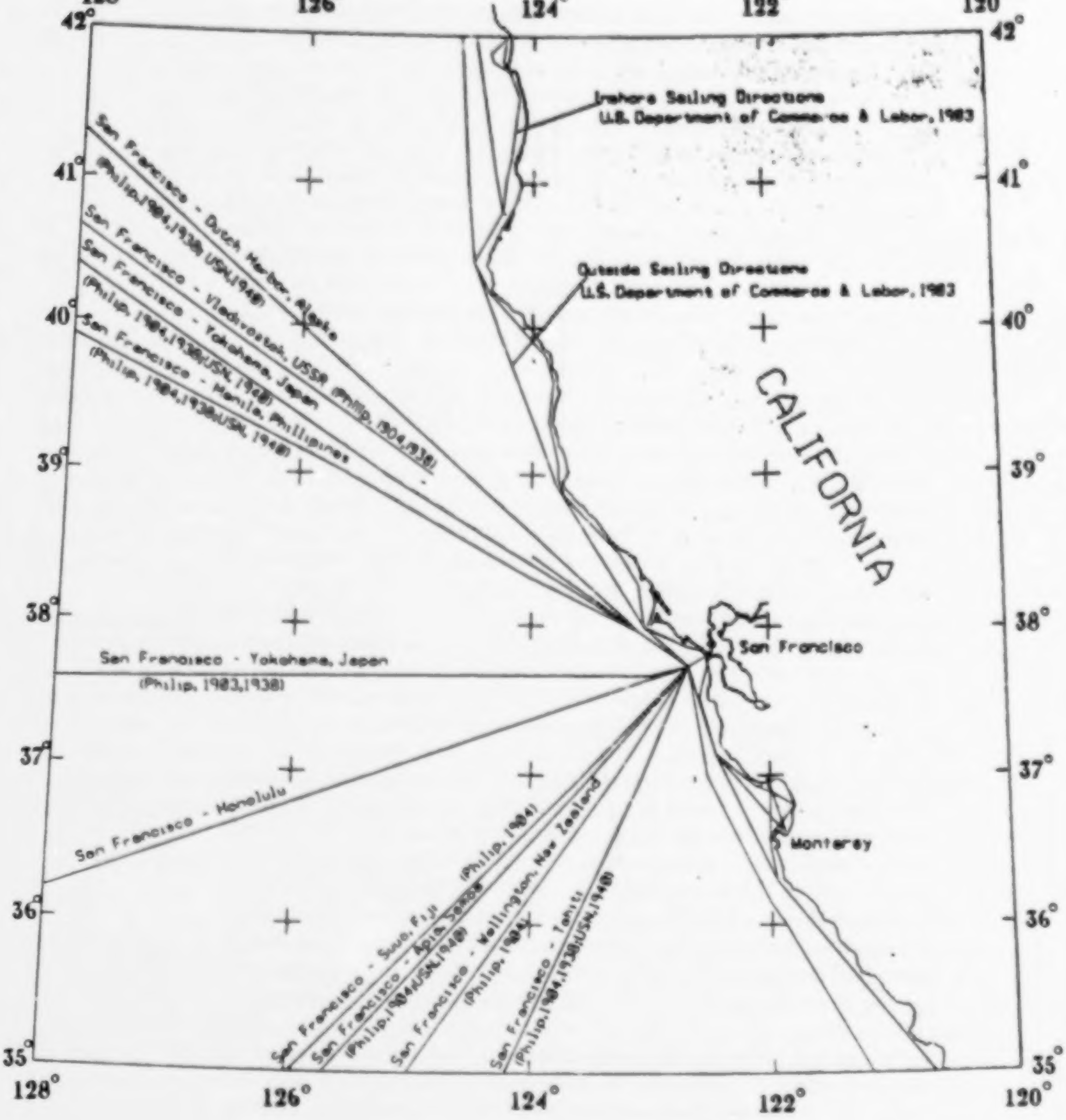

128°
126°
124°
122°
120°
42°
41°
40°
39°
38°
37°
36°
35°
Inshore Sailing Directions
U.S. Department of Commerce & Labor, 1983
Outside Sailing Directions
U.S. Department of Commerce & Labor, 1983
CALIFORNIA
San Francisco
Monterey
San Francisco - Dutch Harbor, Alaska
(Philip, 1984, 1938; USN, 1948)
San Francisco - Vladivostok, USSR (Philip, 1904, 1938)
San Francisco - Yokohama, Japan
(Philip, 1984, 1938; USN, 1948)
San Francisco - Manila, Phillipines
(Philip, 1984, 1938; USN, 1948)
San Francisco - Yokohama, Japan
(Philip, 1983, 1938)
San Francisco - Honolulu
San Francisco - Suva, Fiji
(Philip, 1984)
San Francisco - Apia, Samoa
(Philip, 1984; USN, 1948)
San Francisco - Wellington, New Zealand
(Philip, 1984)
San Francisco - Tahiti
(Philip, 1984, 1938; USN, 1948)

Figure IV-29b. Major Sealanes in the Study Area.

distinguished, and on a nearer approach to the coast the aids to navigation assist in a more accurate location of a vessel's position.

In foggy weather, often lasting several weeks, a vessel approaching the coast should do so with the greatest caution, as owing to the irregularity of the currents in both direction and velocity, the length of time elapsed since last obtaining sights, and the fact that under conditions of thick or foggy weather the winds are usually light, a vessel's position is very uncertain. Vessels from seaward crossing the outer southerly current and coming under the influence of the inshore northerly current, as a rule find themselves when the weather clears northward of their calculated position. This is particularly true in the vicinity of the Columbia River, Willapa Bay, and Grays Harbor.

Vessels coasting will find, under favorable weather condition, the "Outside Sailing Directions along the Coast" the most direct. These are available for steamers of any draft and for sailing vessels with favorable winds. During the summer months when the northerly winds prevail, northbound steamers may follow, in clear weather, the "Inside Sailing Directions along the Coast." These routes are followed by the majority of the coasting steamers bound northward in summer and lead in smoother water with less wind, the force of which is somewhat moderated by the projecting points of the land. In thick weather, vessels should keep farther offshore, sounding frequently to avoid an inshore set. In southeasterly or southwesterly weather there is little choice of routes, and if the weather is exceptionally heavy it is best to heave-to at a safe distance from shore until the weather moderates.

Sailing vessels bound northward along the coast in summer generally stand well offshore, taking advantage of every favorable slant to make their northing until the prevailing northerly winds lead fair for their port of destination, and in some cases make a higher latitude than their port in order not to fall to leeward of it. This holds good even for vessels from the Hawaiian Islands, which frequently sail nearly due north from the islands before hauling eastward for the coast. When bound southward in summer as direct a course as possible is made, and after leaving Cape Flattery, Cape Blanco is the first point usually sighted.

In winter no rules can be given except to take advantage of every favorable slant of wind, and in case of unsettled weather take the precaution of having plenty of sea room to ride out heavy weather should it come.

The Lead. - Too much importance can not be given to the use of the lead when approaching or sailing along the coast in thick or foggy weather. A high percentage of the wrecks and stranded vessels on the coast is due almost entirely to a failure to obtain frequent and sufficient soundings or of not getting any. The abrupt rise from 100 fathoms to 30 fathoms or less over the greater portion of the coast necessitates frequent casts, and if less than 100 fathoms be obtained, continuous

> sounding until in as shoal a depth as is considered prudent. The failure to use the lead combined with the uncertainty of position, due to chronometer errors or an overconfidence in the position of the vessel from the last sights obtained, constitute the main cause of shipwreck to vessels approaching the coast from seaward. Vessels from seaward, uncertain of their position, on getting less than 100 fathoms should heave-to and await clear weather, sounding frequently to avoid an inshore set (USDCL 1903:30).

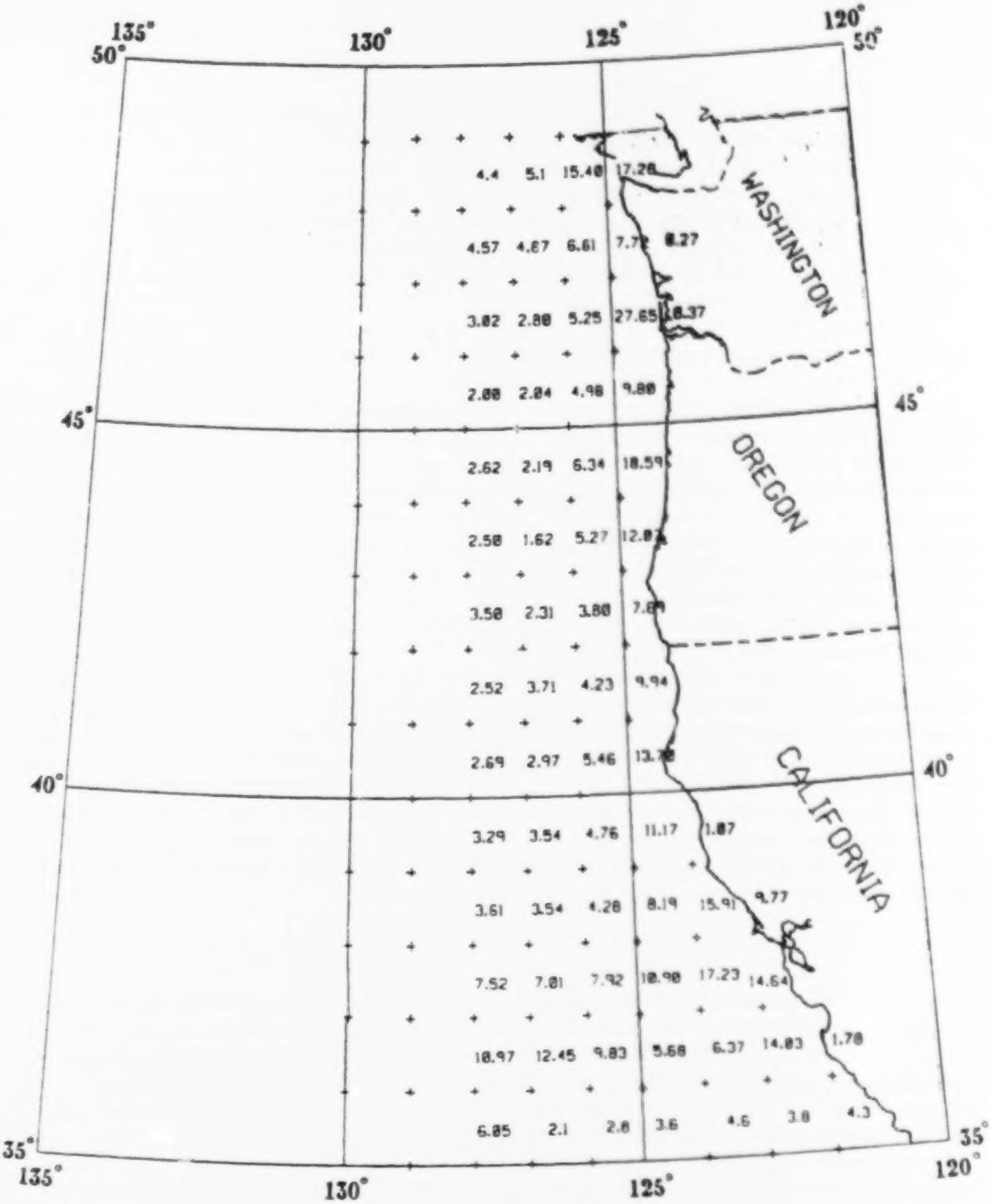
5.4.4 *Recent Traffic Patterns*

Patterns of vessel traffic have not changed significantly in the study area since the advent of steam navigation. Figure IV-30 illustrates the total number of shipboard weather observations reported by USDC (1988) for each 1-degree by 1-degree block of the study area between 1854 and 1985. Since the majority of these observations were made during the last 30 years, we will assume that a total of 3,000 observations would represent a maximum of 100 shipboard weather reports per year. Of course we do not know the frequencies with which various types of vessels report the weather, so we cannot estimate the total volume of vessel traffic across particular areas. Nevertheless, if we assume that there are no significant geographic differences in shipboard weather reporting practices, then Figure IV-30 provides a reasonably accurate representation of modern vessel traffic patterns.

Based upon Figure IV-30, it appears that the coastal sealanes have a significantly higher density of vessel traffic than do the transpacific routes. A notable exception to this pattern is the seaward extension of high traffic density west/southwest from San Francisco. The seemingly inordinate number of weather observations near the mouth of the Columbia River is due to the fact that the river mouth is located within a single 1-degree by 1-degree block as defined by USDC (1988). San Francisco Bay, on the other hand, occupies more than one block, thus the density of observations near the harbor approach is downplayed. In general, however, the number of observations near harbor mouths may have been exaggerated somewhat by the practice of making routine observations from lightships anchored in such area.

5.5 Known Wreck Distribution

Undoubtedly one of the best indicators as to where shipwrecks are likely to occur is the distribution of where wrecks have already occurred. The locations of known historic sites on the continental shelf have been plotted on a series of Historic Site Location Maps in Volume V. The vast majority of these historic sites are shipwreck sites, thus for all intents and purposes, these maps illustrate the distribution of known shipwrecks in the study area. The small-scale Historic Site Location Maps in Volume V are not keyed to the shipwreck database in any way. They serve only to illustrate the overall distribution of wrecks. A more detailed set of Historic Site Location Maps is contained in the large-scale Continental Shelf Atlas provided to MMS for in-house use. The latter set of maps shows the same wreck locations with the addition of a map reference number, keyed to the corresponding shipwreck record in the MMS shipwreck database, and a location accuracy code. The Continental Shelf Atlas was not produced for public distribution; however, qualified researchers may obtain information from the shipwreck database pertaining to specific areas of the study area by addressing inquiries to:


135°
50°
130°
125°
120°
50°
WASHINGTON
OREGON
CALIFORNIA
45°
45°
40°
40°
35°
135°
130°
125°
35°
120°
4.4 5.1 15.40 17.20
4.57 4.87 6.61 7.7 0.27
3.02 2.00 5.25 27.65 0.37
2.00 2.04 4.98 9.00
2.62 2.19 6.34 10.59
2.50 1.62 5.27 12.0
3.50 2.31 3.00 7.8
2.52 3.71 4.23 9.94
2.69 2.97 5.46 13.7
3.29 3.54 4.76 11.17 1.07
3.61 3.54 4.20 8.19 15.91 9.77
7.52 7.01 7.92 10.90 17.23 14.64
10.97 12.45 9.03 5.60 6.37 14.03 1.70
6.05 2.1 2.0 3.6 4.6 3.0 4.3

Numeric data from U.S. Department of Commerce, 1988 (In 1000's)

Figure IV-30. Total Shipboard Weather Observations, 1854-1985.

Chief, Environmental Studies Section
Minerals Management Service
Pacific OCS Region
770 Paseo Camarillo
Camarillo, California 93010

A summary of the relationship between the shipwreck database and the large-scale Continental Shelf Atlas is provided in Appendix G.

The approximate distribution of known wrecks in the study area can be seen on the Historic Site Location Maps in Volume V. It is immediately apparent that vessels tend to be lost most frequently in proximity to the coast, especially near headlands and harbors. The major factors contributing to this distribution are related to the physical environment and to vessel traffic patterns. For example, the concentration of wrecks near seaports is not surprising considering the added risk of navigating in and out of harbors. In harbor settings, vessels are sailing relatively near to the shoreline, often in or close to shallow water. The hazards of harbor navigation often may have been compounded by variable winds, waves and currents. When navigating the inshore coastal routes, headlands and associated rock reefs were a major hazard. In order to minimize sailing time, vessels frequently skirted headlands at a close distance. In marginal weather, navigation around headlands could quickly turn to disaster (see excerpt from Pacific Coast Pilot regarding coastal navigation in Section 5.4.3 above).

As stated above, the distribution of wrecks suggests that the vast majority occurred in the vicinity of the coastline. In order to effectively manage these wrecks as cultural resources, a more refined understanding of their distribution is needed than can be obtained from the Historic Site Location Maps. For instance, the OCS lease block area extends seaward from the states' three-mile jurisdictional limits. Can one reliably estimate the relative frequency of wrecks occurring inside versus outside of this limit? Although three miles is an arbitrary distance with no relation to the physiography of the study area, a reasonably close approximation might be achieved using the nearshore/offshore distinction as defined for this study. The vast majority of wrecks indicated along the coastline of the study area probably occurred in less than 10 m of water, that is very close to the coast where navigational hazards are numerous. Nevertheless, coastwise and transpacific vessels spent the majority of their time offshore (i.e., in unprotected waters greater than 10-m deep) where high seas and strong winds were a frequent cause of marine casualties.

Historic accounts of vessel loss often make a distinction between nearshore (e.g.,"surf zone" or "on the rocks") versus offshore regarding wreck location. Various estimates as to the percentage of shipwrecks occurring offshore versus in the nearshore zone range from 2 percent by Marx (1971 cited in Garrison et al. 1989), taking into account all major wrecks in the western hemisphere, to 25 percent for the Gulf of Mexico (Garrison et al. 1989:II-118). One would expect less frequent offshore vessel losses in the study area than in the Gulf of Mexico due to major differences in the configurations of the coastlines in the two areas. In the Gulf of Mexico, a great deal of sailing time could often be saved by traversing open water as opposed to staying near the coast. Along the coast of the study area, on the other hand, most open stretches of water could be avoided by following the more protected inside coastal routes without adding as significantly to the passage time. Bascom (1976 cited in Garrison et al. 1989) estimated a slightly lower figure of 20 percent for offshore shipwreck frequency based upon a study of 19th-century vessel losses reported by Lloyds of London.

Several cultural resource studies have been conducted by the Portland District, (USCE 1985, 1987a, 1987b, 1988a, 1988b, 1989) in connection with ocean dredging and disposal of dredged material. As a result of these studies, archaeologists with the Portland District have compiled an extensive database of shipwrecks and developed a predictive model for shipwreck locations along the Oregon coast. The model developed by the Portland District relies on the distribution of known shipwrecks to predict the locations of undocumented wrecks.

Portland District archaeologists found the distribution of known wrecks along the Oregon coast to be one of rapidly decreasing frequency as one moves seaward from the shoreline. The Portland District model defines three levels of probability for the occurrence of wrecks: 1) the zone of highest probability consists of the beach and former surf zones where the shoreline has migrated seaward; 2) the zone of next highest probability includes the existing surf zone and areas encompassing shoals and rocks; and 3) the zone of least probability is everything seaward of the above zones where water depths are sufficient for unobstructed navigation. In their most recent study of the Umpqua River mouth (USCE 1989), they found that, of 51 known wrecks in their study area (extending 2 miles north, 10 miles south and 20 miles seaward of the mouth), 55 percent wrecked on the beach, 3 percent in the surf, 16 percent on the river bar; 12 percent in the estuary, and 10 percent offshore. One wreck occurred on the jetty and one was unaccounted for. Ninety-six percent wrecked within 1.5 mile of the mouth, indicating that the density of vessel traffic and the increased hazards of navigating river mouths were likely significant factors contributing toward this distribution. Between 80 and 90 percent of the wrecks identified by the Portland District's research occurred in what we have termed the nearshore zone.

Perhaps the best source of statistics for estimating the percentage of wreck sites occurring offshore versus nearshore for the study area remains the U.S. Life-Saving Service Annual Reports (summarized in Section 5.2 and tables IV-3 and IV-4, above). Based upon an analysis of these statistics, the proportion of offshore vessel losses in the study area is estimated to be at least 9 percent; while the percentage of wreck sites occurring in the nearshore zone may be as high as 75 percent. The balance of wrecks would occur in high traffic areas including harbors and harbor approach settings (Table IV-4). Many wrecks occurring along harbor approaches presumably would be located offshore, as defined here, although it would be difficult to quantify the number of offshore wreck or the likely distribution of these wrecks near harbor months.

The distribution of wrecks laterally along the coast should also be of concern to cultural resource managers, as significant differences exist in the density of shipwrecks along various coastal segments. Such differences no doubt reflect the distribution of substantial harbors that attracted economic development. The distribution of wrecks up and down the coast is summarized by county in Table IV-1. Counties are the smallest geographic division made in the MMS database. For the entire OCS Pacific Region (the study area plus southern California), 3,516 unique wreck listings contain entries for the county segment off of which each occurs. The study area contains approximately 2,705 of these, most of which are represented on the historic site location maps in Volume V. Table IV-1 presents several statistics for each county, including the total number of wrecks in the database for each, the percentage of total wrecks having a county designation that this represents, and the number of wrecks per linear mile of open coastline in each county.

As expected, the highest proportion of shipwrecks are associated with counties in which major harbors are located. The highest percentages of wreck sites for the study area, in descending order, are associated with Clatsop, Coos, Marin, Mendocino, San Francisco and Humbolt counties. The sequence of these counties does not, however, reflect the density of shipwrecks within each county, as their coastlines vary in length. Some counties, such as Mendocino, have a relatively large number of shipwrecks by lieu of the fact that they are counties with very long coastlines. Notice also that Los Angeles County has the highest number of wrecks listed in the database of any county along the Pacific Coast of the lower 48 states, yet Los Angeles did not become a major port until the twentieth century.

In order to provide a more accurate indicator of wreck density, the total number of wrecks for each county was divided by the county's approximate linear mileage of open coastline to obtain wrecks per mile. Linear mileage was scaled from project areas maps. When making mileage estimates, the coastline was assumed to be smoothly curving. In other words the intricasies of convoluted coastlines that can add up to many miles were ignored. Likewise bays and estuaries were bypassed at their entrances. The large number of miles added to a county's shoreline by including bays would tend to deemphasize the density of wrecks occurring there. Excluding bays undoubtedly exaggerates the density, however,this is believed to be justifiable. Exaggerated wreck density for counties having major harbors serve to emphasize the attractiveness of these coastal segments to shipping, and to shipwrecks, precisely because of the presence of these harbors. Also, the miles of shoreline in a harbor may bear no relation to its desirability, thus excluding all harbor shoreline mileage from the statistics in Table IV-1 should allow a more even comparison between counties having harbors, for example, Los Angles, San Francisco and Clatsop counties. From Table IV-1 one can see that the density of shipwreck sites is significantly greater in counties containing harbors than in counties without harbors.

5.6 Historic Site Predictive Zones

The predictive model for vessel loss is based upon three variables: 1) the distribution of known wrecks; 2) patterns of vessel traffic; and 3) severity of weather. These variables are listed in the order of their importance for predicting locations of archaeological wreck sites. The rationale behind the use and relative importance of these variables has been explained at length above. The probability zones derived using these variables are described below in Section 5.6.2.

The most simplistic of similar predictive models have had at least three levels of probability for the occurrence of wreck sites, these being: 1) high, 2) medium; and 3) low. Given the presently employed options for historic archaeological recommendations on the OCS (see discussion in Volume I), this may be as complex as the model needs to be. The scheme proposed here is slightly more complex and, hopefully, more closely reflects actual probabilities for the occurrence of shipwrecks.

Probability areas have been delineated on a series of Historic Site Predictive Zone Maps in Volume V. The boundaries for each zone have been drawn based upon the preceding discussion of environment, historic vessel traffic and known wreck distribution. Areas having typically severe weather conditions, abundant vessel traffic, and a high density of known shipwrecks are assumed to have a higher probability for the presence of undocumented wrecks than are areas meeting fewer of these criteria.

Eleven levels of probability are proposed for the predictive zones illustrated in Volume V (Table IV-5). These zones are based to a large degree upon empirical information; however, they are necessarily subjective. No attempt has been made to calculate actual probabilities to correspond with each zone. The numbering system for these eleven zones uses a combination of arabic numerals and lower case letters, thus the zones are numbered, from lowest to highest probability: 1, 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, 6a and 6b. Arabic numerals indicate relative density of vessel traffic and/or known wreck distribution. Letters indicate relative frequency of significant weather conditions. Notice that weather plays a secondary role to the distributions of known wrecks and historic vessel traffic in this numbering system.

Significant (i.e., severe) weather conditions have been defined after a careful examination of weather summary charts discussed in Section 5.3. Only wind and visibility have been used to characterize weather conditions in this model. Wave height has been excluded due to its strong correlation with wind. Those portions of the study area having either: 1) an average annual wind speed of greater than 15 knots; or 2) an average annual frequency of low visibility, due to fog, exceeding 6 percent in nearshore and harbor settings, have been classified for the purposes of this study as having frequently severe, significant or hazardous weather conditions conducive to the occurrence of marine casualties and vessel loss (see figures IV-20 and IV-24). Such areas are indicated by a lower case letter "b" on the shipwreck predictive zone maps in Volume V. Since

TABLE IV-5

EXPLANATION OF HISTORIC SITE PREDICTIVE ZONES

	Average Annual Wind Speed Less Than 15 Knots and Low Visibility Less Than 6% of Year	Increasing Probability for Shipwrecks →	Average Annual Wind Speed Greater Than 15 Knots or Low Visibility Greater Than 6% of Year
Increasing Probability for Shipwrecks ↓	1	Low-traffic areas	1
	2a	5-nm-wide sailing route buffer adjacent steam routes	2b*
	3a	Transpacific steam routes having a single primary destination	3b*
	4a	Transpacific steam routes having multiple destinations (intersecting or touching upon other sealanes); coastal sealanes	4b*
	5a	Nearshore zone along open coast (excluding headlands); offshore harbor approaches; (seaward of harbor bars)	5b
	6a	Nearshore zone adjacent headlands; harbor bars; wharf areas; inner harbor waters	6b

* Designated 2a, 3a or 4a if low visibility is the only significant weather factor. This is due to a low probability for vessel collisions in lower-traffic offshore areas.

low visibility is not likely to sink ships except in high-traffic areas or along the coast, offshore areas (outside of harbors and harbor approaches) having low visibility and low winds are designated with a lower case "a", indicating more favorable sailing conditions. Portions of the study area not described above are characterized by low winds and high visibility. Such areas are also designated by a lower case "a", implying fair weather and favorable sailing conditions. By these definitions, only a small portion of the study area, located offshore of south-central California, is classified as having characteristically fair weather and fair sailing conditions (refer to figures IV-20 and IV-24).

The use of the above criteria may appear to be biased toward non-favorable weather conditions and to paint a picture of constant danger to ships sailing in northern waters of the study area. Such was not the case nor the intention. For example, as described in Section 5.3, weather conditions off of the Oregon and Washington coasts during the summer months are typically mild. Notwithstanding this fact, weather conditions on the average tend toward high winds from Cape Mendocino northward. Similarly, Cape Flattery and San Francisco are not without their clear weather days, while the Oregon coast has days of near zero visibility due to fog. The above definitions do not preclude severe weather in any area. They merely reflect frequencies or average conditions. The difference between low visibility occurring 6 percent of the year (22 days) versus 4 percent of the year (15 days) seems slight, except when we consider that fog accounts for an estimated 13.1 percent of all vessel losses. All other factors being equal, losses due to fog should occur 50 percent more frequently in areas having 22 days of low visibility versus areas having 15 days of low visibility annually. Over the course of many years, this could result in a significant difference in the number of fog-related vessel losses.

Having explained the rationale behind zones designated "a" versus "b" as regards weather, we shall proceed with describing the criteria of vessel traffic and known wreck distribution that correspond to each of the predictive zones' six Arabic numbers. Consult Table IV-4 above for estimated frequencies of archaeological wreck sites occurring within each major physiographic area (offshore, nearshore and harbors).

Zone 1. This zone consists entirely of those offshore waters having the lowest density of vessel traffic. By definition, there is no possibility for vessels to strand in Zone 1 and very little possibility for a collision to occur due to the relatively low density of vessel traffic. A small number of vessels have likely been lost by foundering in Zone 1; however, their locations could only be predicted based upon proximity to sealanes (i.e., designating additional zones parallel to Zone 2) or on a case by case basis if the identities of particular vessels were known.

Zone 2. This zone consists of a 5-nautical mile-wide buffer alongside all sealanes. This zone was designed to compensate for two factors: 1) the broad nature of sealanes during the age of sail: and 2) the fact that vessels may founder well-outside of their intended sealanes when blown off course by storm winds. The probability for wrecks occurring within Zone 2 is considered only slightly less than that for Zone 3.

Zone 3. All transpacific sealanes fall into Zone 3, except where they intersect or touch upon another sealane. Intersecting areas fall into Zone 4 due to the relative increase in the density of vessel traffic. One would expect the number of founderings to be lower in Zone 3 than in Zone 4 due to the decrease in vessel traffic density. The incidence of collisions in Zone 3 should be near zero percent.

Zone 4. This zone consists of all sealanes having a relatively high density of vessel traffic. Sealane width for transpacific routes has been standardized at 10 nautical miles based upon the width of steamer routes charted by Maury in his mid-nineteenth-century Track Charts of the north Atlantic. Coastal sealanes include an area five nautical miles seaward from the charted centerline of the route and include all of the waters between the route centerline and the 10-m isobath. All coastal routes are considered to have multiple destinations and heavy traffic, and thus are included in Zone 4. Likewise, all transpacific routes intersecting or touching upon another sealane have been placed into Zone 4. Due to the generally higher density of vessel traffic in

Zone 4, a relatively high number of founderings can be expected. Although low by comparison with Zone 6, the incidence of collisions between vessels should be higher in Zone 4 than in other offshore areas.

Zone 5. Zone 5 consists of the nearshore zone (less than 10 m deep) along the open coastline, excluding headlands, and outside harbor approaches, up to but not including harbor bars. The largest number of shipwrecks occurred in the nearshore zone due to strandings. Zone 5 is assigned a lower probability than headlands due to a number of factors. First of all, the density of known wrecks is greater along headlands. Secondly, vessel traffic is less concentrated opposite straight or concave coastlines than adjacent headlands. Finally, vessels tend to operate farther from shore adjacent beaches than they do along headlands, thus there is generally a greater margin for error when navigating along beaches. Non-headland, nearshore areas that have a high density of vessel traffic operating near the open coast, for example, the inside southern approach to San Francisco Bay, have been assigned to Zone 6. Such is the case for the nearshore area outside of most harbor entrances.

Zone 6. This zone consists of nearshore areas adjacent headlands and harbor mouths, as well as all harbor waters out to and including harbor bars. The highest density of historic vessel traffic in the study area was, in descending order, at harbor entrances, in sheltered harbor waters, and in the vicinity of headlands. The latter does not seem immediately obvious; however, traffic on the inside coastal routes became concentrated near to the shore in a relatively constricted sealane when cutting corners around headlands. Due to high traffic density in or adjacent zones designated with a "6", one would expect a high frequency of both collisions and "other" casualties. Due to proximity to bars, jetties and rock reefs, one would expect a high frequency of strandings. Due to the exaggerated wave height across harbor bars, one would expect a high frequency of founderings. The combined expected high frequencies of shipwrecks in these areas is well-reflected by the distribution of known wrecks (see Volume V, Historic Site Location Maps). All known wrecks having an accuracy code of A, B or C are included in Zone 6 out to a distance equal to the radius suggested by the accuracy code for offshore locations or laterally for the same distance along the coast if the wreck is plotted in the nearshore zone. Zone 6 is implied around these offshore wrecks and has purposely not been drawn on the Historic Site Predictive Zone Maps.

With the exception of harbor approaches and harbor mouths, zones 5 and 6 are limited to what has been defined as the nearshore area. Zones 1, 2, 3 and 4 are confined to the offshore area (everything greater than 10 m deep except harbor approaches and inner harbor waters). In offshore areas there are, by definition, no obstructions to navigation other than vessels. Except in the vicinity of major harbors, there are so few known shipwrecks offshore that their distribution has little predictive value. As a result, traffic and weather become the most significant predictors of shipwreck locations in offshore areas.

6.0 SUMMARY

The predictive model developed in this volume was used as the basis for mapping predictive zones for potential historic site occurrence on the continental shelf. The vast majority of historic sites in the submerged portions of the study area are shipwreck sites or sites associated with maritime activities. The latter include sites where cargo was lost or jettisoned as well as sites where vessels wrecked but were later broken up for salvage or refloated after discarding ballast and cargo. Three types of information were utilized in formulating the model: 1) the distribution of known shipwrecks; 2) vessel traffic patterns; and 3) environmental factors affecting marine navigation. The most significant environmental factors affecting navigation are, in descending order of importance: a) physical barriers to navigation, including the shoreline, rocks, reefs and shoals (and other vessels); b) high winds and/or heavy seas (generally, but not always, associated with one another); and c) low visibility due to fog.

Approximately 3,850 shipwrecks have been historically documented for the study area. It is estimated that between 80 and 90 percent of these occurred in less than 10 m of water in what we have referred to as the nearshore zone. The balance of wrecks have occurred in offshore or harbor waters greater than 10 m deep. Harbor entrances and the nearshore zone adjacent headlands are the most likely areas for the occurrence of shipwrecks. The most likely locations for offshore wrecks are harbor approaches and high-traffic areas or constricted sealanes. The potential for preservation of vessel remains and artifacts in association with shipwreck sites is generally good, even in high wave-energy shoreline environments, due to cool water temperatures.

Mineral exploration and development is most likely to impact wrecks occurring in offshore areas, although pipelines and mineral-related coastal facilities may impact wrecks in state waters (inside of the three-mile geographical limit), including the nearshore zone where a relatively higher concentration of shipwrecks is known to occur. The abundance of shipwreck sites occurring outside of the MMS leasing area suggests that much of the responsibility for CRM on the continental shelf must fall upon other agencies in addition to MMS. For example, the U.S. Army Corps of Engineers is faced with responsibility for CRM compliance in the immediate vicinity of Federal navigation projects. The National Park Service is responsible for cultural resources in Federal park lands. The National Oceanographic and Atmospheric Administration is responsible for National Marine Sanctuaries. Marine CRM requirements for compliance with Section 106 of the National Historic Preservation Act presently lag behind similar requirements for cultural resources in terrestrial settings. This situation is due partly to a lack of understanding regarding the quantity, quality and distribution of submerged cultural resources. Hopefully, this study will assist Federal and state agencies in recognizing and properly managing the diversity of submerged cultural resources to be found on the continental shelf off of Washington, Oregon and California. More stringent survey and reporting requirements by these agencies should result in overall improvements to our knowledge of continental shelf archaeology.

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